APPENDIX D

ANALYTICAL APPROACH, METHODS, AND BIOLOGICAL OPINION GAP ANALYSIS SURVIVAL RESULTS FOR THE SNAKE RIVER AND UPPER COLUMBIA RIVER LISTED SALMON AND STEELHEAD ESUs

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1.0 PURPOSE AND BACKGROUND

1.1 PURPOSE

The purpose of this paper is to describe the analysis used to distinguish the effects of the existence of the FCRPS hydro power system and its non-discretionary operations from the effects of the discretionary annual operations and authorized purposes of the FCRPS, since only the latter is the subject of ESA consultation. This paper will describe the methods, analytical approach, and modeling survival results for the following ESUs: Snake River (SR) spring/summer chinook salmon, Upper Columbia River (UCR) and Lower Columbia River (LCR) spring chinook salmon, SR steelhead, and UCR, Mid-Columbia River (MCR), and LCR steelhead. As explained below, a similar quantitative analysis was not conducted for SR fall chinook salmon.

1.2 ANALYTICAL APPROACH AND BACKGROUND

For purposes of this consultation, NOAA Fisheries must estimate the effects attributable to the FCRPS environmental baseline. The first step is to establish a reference operation to which the considerations for the limits of Action Agency discretion may be qualitatively applied. The value of this reference operation and analytical method described herein is to describe a mortality rate attributable to the existing configuration of the FCRPS that is a "conservative" estimate, e.g., one that is most protective, giving the benefit of the doubt to the listed species, and provides the basis for a quantitative assessment of the environmental baseline hydro effects (see Section 5.2 in the 2004 FCRPS Biological Opinion for a more complete description of the environmental baseline and reference operation).

By comparing the reference operation to the Action Agencies' proposed hydro operation and system configuration improvements, the incremental effect of discretionary annual hydro operations can be estimated. The relative difference in survival rates between these two operations is referred to as a "gap," and the method of estimating this gap is referred to as a "gap analysis." Under this approach, NOAA Fisheries has defined a reference operation of the existing FCRPS structures that is most conservative for the listed species to quantitatively estimate a "reference survival rate" as a starting point for a qualitative assessment of environmental baseline effects. Since four federal mainstem "collector" dams are currently configured to collect and load listed juvenile fish into barges for transport around FCRPS projects, the reference operation also includes a transportation operation that utilizes existing fish passage facilities to the extent that, in NOAA Fisheries' judgment, transportation of listed fish results in higher survival.

NOAA Fisheries used its Simulated Passage (SIMPAS) spreadsheet model to estimate and compare the survival rates resulting from this reference operation to the survival rates estimated for the Action Agencies' proposed hydro operations and fish passage facilities in 2004, 2010 and 2014, which is intended to implement current 2000 FCRPS Biological Opinion operations and future system configuration changes while achieving all authorized project purposes. The relative differences in survival identified by this method of comparison, or gap analysis, represent the effects to the listed species that may be attributable to the existence of the dams and the Action Agencies' proposed near- (2004-2009), intermediate- (2010-2013) and long-term (2014) hydro operations and system configuration changes.

The SIMPAS spreadsheet model, developed by staff in the Hydro Division of NOAA Fisheries' Northwest Region, is a fish passage accounting model that apportions the listed species to various passage routes (i.e., turbines, fish bypass system, sluiceway/surface bypass, spillway, and/or fish transportation) based on empirical data and input assumptions for fish passage parameters. The model accounts for "successful fish passage" (survival) and "losses" (mortalities) through each of the alternative passage routes to estimate survival past each project. The model also accounts for the proportions of juvenile fish transported and left to migrate in-river. The model provides survival estimates at each project (dam plus pool) and throughout the FCRPS (from the head of Lower Granite Reservoir to the tailrace of Bonneville Dam).

Together with the Action Agencies, NOAA Fisheries reviewed and analyzed fish passage assumptions used in the previous SIMPAS model fish passage modeling exercises, including those developed and used in the 2000 FCRPS Biological Opinion, comments received from the salmon Comanagers during the public comment period on the draft 2004 Opinion, and the most recent empirical data to determine appropriate fish passage parameters for input into the SIMPAS model for the survival gap analysis. NOAA Fisheries also reviewed and used the latest compilation of fish passage information contained in the technical memos recently prepared by the Northwest Fisheries Science Center (NWFSC):

- "Passage of Adult and Juvenile Salmon Through Federal Columbia River Power System Dams" (Ferguson *et al*. 2004)

- "Effects of the Federal Columbia River Power System on Salmon Populations" (Williams *et al*. 2004)

Examples of fish passage parameters reviewed by the NOAA Fisheries and Action Agency staff include spill efficiency, fish guidance efficiency, spill/gas caps, turbine survival, spillway survival, sluiceway survival, bypass system survival, and diel passage patterns. The parameter values were quantified for each FCRPS dam and for SR steelhead, spring and fall chinook salmon (considered indicator species for the spring and summer passage seasons, respectively). The parameter values selected for modeling the proposed action and the reference operation represent the best available scientific information, and, in cases where empirical information was unavailable, outdated, or limited, represent NOAA Fisheries' best professional judgment.

There are limitations in modeling juvenile fish survival based solely on empirical data gathered during a single year. This is because fish passage conditions differ from year to year, environmentally as well as operationally and structurally. Flow, temperature, runoff timing, fish condition, spill levels, and use of extended- versus standard-length screens in turbine intakes or removable spillway weirs (RSWs) in spillways are some of the factors that can change. To address these limitations, the NOAA Fisheries staff used all the most recent empirical passive integrated transponder (PIT)-tag reach survival information collected from 1994 through 2003 to evaluate a wide range of fish passage and environmental conditions for yearling and subyearling chinook and steelhead. Because water conditions during this 10-year period ranged from low flow (in 2001) to high flow (1997), this approach demonstrated the modeled variation in juvenile passage survival resulting from different environmental (and the resulting operational) conditions.

1.2.1 DEVELOPMENT AND HISTORY OF SIMPAS SPREADSHEET MODEL

The SIMPAS (simulated passage) spreadsheet model was first developed by NOAA Fisheries' Hydro Division staff to evaluate potential actions for the 1995 FCRPS Biological Opinion. Since then, it has been used regularly as an analytical tool to evaluate structural or operational measures for their potential to reduce the mortality of juvenile salmon and steelhead at FCRPS projects. In 1999 and 2000, the model was used to fully evaluate the proposed action for the 2000 FCRPS Biological Opinion. More recently, NOAA Fisheries updated the SIMPAS model to accommodate additional passage routes (for example, RSWs and surface bypass routes) and to more accurately account for passage efficiency through spillways and sluiceways. Also, a predation adjustment factor was added to adjust the pool survival estimate for factors, such as forebay delay, that may change the base pool survival estimate.

The SIMPAS model starts with a group of fish (1.00) and applies an estimated pool survival to these fish prior to their reaching a mainstem federal hydropower project. The model then assigns the surviving fish to various routes of passage at the project, applies an estimated survival rate for the respective routes of passage, removes the estimated proportion of fish that are transported from a given project (if it is a collector project), and then recombines the surviving fish in the tailrace of the project. This process is repeated for each additional FCRPS mainstem Snake and Columbia River hydropower project. Fish guidance and survival estimates are typically averages of empirically measured rates through various routes of dam passage (or derived from average fish passage efficiency estimates) or various reservoir pools. When empirically based estimates are not available, passage parameter estimates are obtained from studies at other similar projects or from best professional judgment.

For each species, model input includes:

- Seasonal average flows and spill levels
- Pool survival estimates including a predation adjustment factor
- Average spill, sluiceway, and bypass guidance efficiency estimates
- Average survival rates through various passage routes and reservoirs

For each species, model output estimates include:

- Proportion of fish transported and left in-river
- Project-specific and system survival estimates
- Fish passage efficiency at each project
- Mortality due to passage through turbines

1.2.2 USE OF THE SIMPAS MODEL

The SIMPAS model is a useful analytical tool to enable screening of alternative fish passage alternatives. However, there are a number of important caveats to the appropriate use of SIMPAS modeling results. These include:

- The juvenile survival rates shown in Tables D.51 through D.59 are based on juvenile passage and survival studies only and should not be used to infer the likelihood of adult returns.

- The juvenile survival rates shown, as well as the input passage parameters, are point estimates, i.e., confidence intervals are not calculated or implied.

- The model does not contain a time-step function, so both inputs and outputs are scaled to seasonal averages.

- Where possible, data from several years of studies were averaged, however, in many cases data from only one year of study was available. In such cases, the single year data may not represent passage conditions under a broad range of environmental conditions.

- Best professional judgment was used to develop some of the passage parameters, e.g., in some cases, fish passage data gathered at one dam during a single passage season were applied to several other similar hydrosystem projects or for future system configuration alternatives.

In addition, the reach survival data available for initial setup of the SIMPAS model and for estimating reservoir effects are limited to NOAA Fisheries PIT-tag data collected between 1994 and 2003. These years represent a wide range in flow and environmental conditions, from one of the highest flow years (1997) to one of the lowest flow years (2001) on record (Attachment 1). In several years, reach survival data were extrapolated from some of the upper projects in the Snake River (on a per-mile basis) to the entire system (see discussion in the Pool Survival section below and Attachment 3). The reach survival estimates are point estimates roughly classified by the volume of runoff during the year in which the data were collected. These survival estimates do not represent the kind of multi-year analysis that ideally would be used to estimate the range of reach survival rates expected under a 50-year record of flow conditions. They do, however, provide a general sense of the between-year variation observed in the last 10 years, which encompass a range of flow and environmental conditions similar to the 50-year flow record.

In the initial setup phase, SIMPAS uses the empirical or empirically derived reach survival estimates and the passage route survival data to determine separate pool and dam survival estimates. In the initial setup phase and in the retro analyses, the combination of pool and dam survival estimates are set to equal the best available reach survival estimates for the specific year and reach.

Although there may be some uncertainty about the accuracy of the resulting pool and dam survival estimates, NOAA Fisheries determined that the model output for 1994 through 2003 was reasonable and produced useful pool survival estimates. Once the model was set to empirical data in the retrospective operation and then used to determine the estimated survivals under the reference operation, NOAA Fisheries considered it had a reasonable reference, or baseline, condition from which to make comparisons of additional operational alternatives of current (2004) and potential future (2010 and 2014) juvenile fish passage actions proposed by the Action Agencies over a wide range of water conditions represented by water years 1994 to 2003 (see Tables D.51 to D. 59 for SIMPAS model survival gap analysis results of alternative proposed hydro operations and actions for various listed species).

Other juvenile fish passage and survival models attempting to characterize these same effects have relied on flow/survival, temperature or travel time/predation relationships applied to a simulated monthly flow condition. Each approach has its own limitations. On balance, however, NOAA Fisheries has determined that this relatively simple and straightforward approach made the best use of the most recent empirical survival information and was adequate for the purposes of this analysis. The framework for this analysis is also consistent with the monitoring and evaluation program described in the Action Agencies' UPA and Appendix E; therefore, as additional survival information is collected for various listed species, it can be incorporated directly into future versions of the SIMPAS model.

A number of reviewers commented on the shortcomings of the SIMPAS model. For example, commenters stated that the model: is too simple; is not a life cycle model; was designed to be used in a qualitative rather than relative sense; used only point estimates of survival and passage efficiencies; did not use a time step function; underestimated spill passage at some dams; or overestimated survival for low flow conditions.

To answer these concerns, NOAA Fisheries would first point out that the SIMPAS model is a deterministic analytical tool for use in comparing two or more system (or project) operations or system configuration changes to obtain relative differences in juvenile survival between the head of Lower Granite Pool and the head of the estuary. It is not a life cycle model, nor does it need to be to serve its intended purpose. The differential delayed survival factor "D" for fish transportation is used in the model only as a weighting mechanism to allow a fair recombination of in-river and transported juveniles in the reach below Bonneville Dam. The model is not typically used to determine absolute numbers of surviving juveniles below Bonneville Dam and is not used to estimate the absolute number of returning adults to the Columbia River.

The SIMPAS model is simple on purpose. NOAA Fisheries' goal was to use the model as an analytical tool to provide reasonable relative survival differences between proposed operations or configuration changes and a reference, or baseline, operation, while maintaining a high degree of transparency to reviewers. Incorporating a large number of functional response curves (or sub-models) to try to express temperature, predation, or dissolved gas functions defeats the purpose of a simple modeling approach and would have significantly increased the complexity and decreased the transparency of the model. The model does allow for limited functional response inputs, because specific adjustment factors can be made to the individual pool survival estimates. For example, NOAA Fisheries adjusted pool survival downward to account for a predator response to increased residence time of juvenile fish in the forebays of dams that had spill durations of less than 24 hours. In most cases, given the similarities among all the operations modeled, it is unlikely that sub-models would have significantly changed the relative survival gaps estimated by the model.

NOAA Fisheries notes that a time-step function weighted by fish abundance might improve the ability to determine relative differences between different operations, but only to the extent that the difference in operations is time-step sensitive. For instance, fish guidance efficiency studies have suggested that guidance of turbine intake screen systems decreases as the fish passage season progresses. If a particular operation relied more heavily on screened bypass systems as the passage season progressed, the guidance and collection of fish and potentially the survival of that operation may decrease over time and show a greater "gap" when compared to an operation that relied on a more constant operation. Since all of the operations modeled in the 2004 Opinion were constant for the passage season under consideration, a time-step function would have little if any effect on the final survival gap estimates. Moreover, there is a paucity of empirical data on fish passage parameters that may or may not change over a passage season.

NOAA Fisheries recognizes the importance of using valid, empirical fish passage data in the model. Where empirical data were available, NOAA Fisheries used what were believed to be the best available estimates for passage route survival and passage efficiencies for each possible route of fish passage (Section 1.2). As NOAA Fisheries progressed into comparisons with potential future system configurations, many of the passage and survival estimates were by necessity based on best professional judgments for which there are no confidence interval estimates. Recognizing that this may be a weakness, since the confidence intervals for these point estimates sometimes varies widely, NOAA Fisheries used the same passage route point estimates for both the reference and the 2004 proposed operation. In this base case analysis (which established the initial gap), the degree of uncertainty regarding any particular point estimate was common to both sides of the operational comparisons. These survival or passage parameter point estimates were adjusted upward in the gap analyses of future 2010 and 2014 configurations of the proposed operations. These departures from common data points may add to the uncertainty associated with these future condition gap analyses.

As a means of understanding the risks associated with some of these uncertainties, as well as to address several comments received on the September draft Opinion, NOAA Fisheries conducted some sensitivity analyses using the SIMPAS model. In response to some comments that the reference operation should include higher 24-hour spill levels to further improve survival, even at dams such as Lower Granite with an RSW installed, the first sensitivity studies were conducted using SR steelhead and SR spring/summer chinook salmon. In these reference operation studies, 24-hour spill at Lower Granite Dam with an RSW was increased from 20 kcfs to 45 kcfs total spill to determine relative changes in in-river and system survival with D, and the percent of fish transported, in comparison to the 2004 system configuration and proposed hydro operation, which remained unchanged throughout these studies.

For SR spring/summer chinook, increasing 24-hour spill at Lower Granite resulted in nearly identical average relative differences (within 0.1%) for both in-river and system survival when compared to the average relative survival difference under a reference operation with 20 kcfs total spill, although the percent of fish transported decreased by 5% under the higher spill operation. However, the results of the same sensitivity study for SR steelhead showed that, while the average in-river relative survival gap increased slightly by 0.2%, the relative average system survival with D showed no difference in survival between the reference operation and the proposed 2004 operation under the higher Lower Granite spill assumption, while the reference operation with 20 kcfs spill showed a relative survival difference of -1.3%. Again, between 4-5% more fish remained in-river under the higher spill condition, which resulted in an overall reduction in average system survival with D under that operation when compared to the reference operation with lower spill at Lower Granite Dam. Based on the results of this spill sensitivity study, NOAA Fisheries assumed a 20 kcfs total spill operation at Lower Granite Dam in its reference operation.

Other sensitivity studies were conducted using SR fall chinook salmon. The SIMPAS model includes a relationship between annual survival and annual average flow rates for all three ESUs that are directly modeled. The relationships for SR spring/summer chinook salmon and SR steelhead are based on empirical survival rates through the entire FCRPS. For SR fall chinook salmon, the relationship is based on empirical reach survival rates through the four lower Snake River projects, but empirical reach survival rates are not available through the lower Columbia River projects. Some commenters questioned the use of extrapolated survival data from the Snake River in the lower Columbia River reach. To address this comment, the SIMPAS model was run under two sensitivity analyses. Under the first, the empirical reach survival estimates from the lower Snake River were extrapolated to the lower Columbia River using methods described in Attachment 3. It is possible that this method over-estimates reservoir mortality in the lower Columbia River, because PIT-tagged SR fall chinook salmon have a much faster migration rate through the lower Columbia than through the Snake River, so they may experience less exposure to predation and thus less mortality. Under the second sensitivity analysis, flow is estimated to have no effect on reservoir survival rates in the lower Columbia River, i.e., the Columbia River pool survival rates were assumed to be equal in both the reference and proposed 2004 hydro operations. That analysis may under-estimate the mortality rate under lower flow conditions. The two sensitivity analyses are expected to largely bound the range of reservoir survival rates for SR fall chinook salmon. Again, while the reference operation assumptions were modified, the proposed hydro operation remained unchanged throughout these studies.

The results of these sensitivity analyses showed that, as expected, the average in-river survival rate for SR fall chinook in the reference operation decreased by about 2% under the second sensitivity study, which assumed no flow-survival relationship in the lower Columbia River. In comparing the relative in-river survival differences between the two reference operations and the proposed operation, the relative average in-river survival rate difference was -16.6% (with a range from about -7 to -25%) under a reference operation that used extrapolated survival rates in the lower Columbia River, to -8.4% (with a range of about -5 to -13%) in a reference operation assuming flow has no effect on Columbia pool survival rates. The results of these sensitivity analyses were applied to the relative differences in in-river survival rates discussed in Section 6.4.1.2 of the 2004 Opinion.

During the time period between September and November, when the regional review draft of the 2004 Opinion was released and the completion of the final Opinion, NOAA Fisheries updated several areas of the model. One of the primary improvements was to change the spill efficiency calculations from a step function to an equation based on a response curve. NOAA Fisheries also updated the spill efficiency data used at several of the dams with more recent empirical data. These improvements were incorporated in the model to address and resolve concerns several commenters raised about the model's spill efficiencies.

Another comment addressed the way diel passage rates were used in the model. NOAA Fisheries used the diel passage values from the 2000 FCRPS Biological Opinion in all cases. These diel rates were applied to operations where 12-hour spill occurs or where 24-hour spill was judged insufficient to result in a flat 50/50 day/night passage condition. In all cases where significant levels of daytime spill occur, we used a flat 50/50 diel passage rate.

Another commenter indicated that turbine survival benefits from the Biological Index Testing (BIT) Program should have been included in the reference operation. NOAA Fisheries did not include these turbine survival benefits in the reference operation because the biological turbine index testing has yet to be completed at any dam and therefore, there are no results that could be implemented immediately. However, expected turbine survival improvements due to the biological index testing were assumed in both the 2010 and 2014 gap analyses.

1.2.3 Example of SIMPAS Model Calculations

This simple example, using a single hypothetical project, is provided to illustrate how the model works. The example provides the necessary input parameter estimates, demonstrates the types of calculations made by the SIMPAS model, and provides the model output based on these calculations.

1.2.3.1 SIMPAS Input Parameters

Flow:

- Total project flow = 100 thousand cubic feet per second (kcfs)
- Total project spill = 40 kcfs (24 hours per day)

Project configuration:

- Only three passage routes are available to fish: spillway, fish bypass system, and turbines
- Spill effectiveness (i.e., ratio of fish per unit volume of water through the spillway) = 1.25
- Fish guidance efficiency of turbine intake screens = 50%

Survival estimates:

- Pool survival = 96 %
- Spillway survival = 98 %
- Bypass system survival = 96 %
- Turbine survival = 90 %

1.2.3.2 SIMPAS Calculations and Output

Step 1: Determine proportion of fish arriving at project

Proportion surviving pool and arriving at the project (0.960) = starting proportion (1.000) x pool survival (0.960)

Step 2: Calculate proportion of fish passing via spillway, bypass system, and turbines

Proportion of fish passing via spillway (0.480) = proportion of fish arriving at project (0.960) x proportion of water spilled (0.400) x spill effectiveness (1.250)

Proportion of fish passing via fish bypass system (0.240) = proportion of fish remaining (0.960 - 0.480 = 0.480) x fish guidance efficiency of the turbine screens (0.500)

Proportion of fish passing via turbines (0.240) = proportion of fish remaining (0.960 - 0.480 - 0.240 = 0.240)

Step 3: Calculate the proportion of fish surviving the spillway, bypass system, and turbines

Proportion of fish surviving the spillway (0.470) = proportion of fish passing via spillway (0.480) x survival rate through spillway (0.980)

Proportion of fish surviving the fish bypass system (0.230) = proportion of fish passing via the bypass system (0.240) x survival through the bypass system (0.960)

Proportion of fish surviving the turbines (0.216) = proportion of fish passing via the turbines (0.240) x survival through the turbines (0.900)

Step 4: Calculate the proportion of fish surviving to the project tailrace (assuming project does not collect fish from the fish bypass system for transport)

Proportion of starting population surviving to project tailrace (0.916) = proportion surviving spillway (0.470) + proportion surviving fish bypass system (0.230) + proportion surviving turbines (0.216)

Step 5: Calculate Output Parameters

Proportion of fish surviving the reservoir and project = 0.916 proportion surviving to tailrace (0.916) ÷ starting proportion (1.000) **[**Project survival]

Proportion of fish surviving the dam only = 0.954 proportion surviving to tailrace (0.916) ÷ proportion arriving at the dam (0.960) [Dam passage survival]

Proportion of fish avoiding turbine passage = 0.750 (proportion of fish passing via spillway [0.480] + proportion of fish passing via fish bypass system [0.240]) ÷ proportion of fish arriving at the project (0.960) [Fish passage efficiency]

Proportion of fish killed by turbines at this project = 0.024 proportion of fish passing via turbines (0.240) - proportion of fish surviving turbines (0.216) [Turbine mortality]

2.0 REFERENCE OPERATION

2.1 DESCRIPTION OF THE REFERENCE AND PROPOSED ACTION OPERATIONS

This section describes NOAA Fisheries' approach to defining an operation of the FCRPS that maximizes the survival of listed ESUs using existing dam configurations. The reference operation was developed based on information and data from: (a) the three Northwest Fisheries Science Center (NWFSC) draft technical memoranda; (b) a literature review of available fish passage information, including fish passage information contained in Appendix D of the 2000 Biological Opinion (NMFS 2000); and (c) the best professional judgment of NOAA Fisheries Hydro Division staff. A hypothetical reference operation was developed to maximize survival for all 13 ESUs, including the hatchery/wild mixture of SR juvenile spring/summer chinook salmon, UCR spring chinook salmon, SR steelhead, UCR steelhead, and SR fall chinook salmon. It does not, however, describe an operation that could actually be implemented, since the FCRPS must be operated to meet certain other authorized project purposes, such as flood control and irrigation.

2.1.1 Development of Average Spring Flows for the Reference Operation

For the reference operation, spring flow objectives remain as seasonal average values. The reference operation is based on full use of an unconstrained Federal hydropower system, which allows for a greater degree of Federal storage project flexibility than under the highly regulated regime that normally takes into account the combined constraints of irrigation withdrawals, flood control, and hydropower operations. For the reference operation, the average spring flow target in the Snake River is increased to 110 kcfs over the period from April through June 20. This flow target was based on observed breakpoints on a curve fitted between a flow index and survival for both juvenile SR spring chinook salmon and steelhead (Williams *et al.* 2004). It also factored in the potential value to be gained from reducing the travel time of steelhead through the Snake River. Elevated levels of predation on steelhead by Caspian terns nesting on islands in the McNary pool have been observed in recent years. It is reasonable to assume that a faster downstream migration rate, together with the higher turbidity associated with higher spring flows, would help reduce this predation. Similarly, the average spring flow objective at McNary Dam was increased to 285 kcfs to reduce and thereby improve steelhead travel time through the middle and lower reaches of the Columbia River.

To define a reference operation to maximize fish survival for the 1994-2003 study period, NOAA Fisheries Hydro Division staff (Hydro staff) worked with BPA staff using BPA's hydro-system regulation model (HYDSIM) to evaluate changes in mainstem Snake and Columbia river flows, spills, and storage reservoir elevations resulting from a reference operation under a full range of 50 different water years (1929-1978). This difficult and time-consuming modeling effort required numerous modeling changes and studies to obtain the best reference operation, the priorities of which were to achieve refill of Federal storage projects by June 30, meet summer flow objectives, meet flow objectives in other periods of the year, and reduce forced (involuntary) spill at mainstem dams to minimize excess total dissolved gas. Accordingly, average spring flows were obtained from the 50-year HYDSIM model output flows using a post-processing hydrologic analysis. The flows are shown in Table D.1 (see Attachment 1 for a description of how the 1929-78 output flows were matched to the 1994-2003 time period used in the Biological Opinion).[1]

Based on 50-year reference operation modeling, the average spring flow targets from the 2000 Biological Opinion for the Snake and Columbia rivers were either met or exceeded 72% and 78% of the time, respectively. In the reference operation, refill by June 30 was achieved at Dworshak, Hungry Horse, Libby and Grand Coulee 80%, 50%, 70% and 100% of the time, respectively, in the 50-year record.

The 1994-2003 period was chosen for several reasons:

- A full array of empirical reach survival data is available for SR spring/summer chinook salmon and SR steelhead, facilitating model development and analysis.
- The configuration of the FCRPS was similar to its current configuration.
- The 10-year study period includes a broad range of hydrologic conditions and has a mean annual runoff volume that is very similar to the 50-year average.

Thus, although climate experts expect ongoing global climate change to cause the future hydrologic regime to vary from that observed over the past 50 years, the 10-year study period represents a wide range of hydrologic conditions likely to encompass those expected over the next ten years.

Several of those who commented on the August 2004 draft of this Opinion argued that use of seasonal averages in this survival modeling process underestimates the value of flow. None of the commenters explained why they believe that NOAA Fisheries' use of the seasonal average flow might tend to underestimate the importance of flow to fish survival. NOAA Fisheries notes, however, that the temporal distribution of fish passage at any given project is not a constant, flat rate. Rather, the temporal distribution of fish passage approximates a normal distribution, with very few fish passing early in the migration, increasing to one or more peaks, and gradually declining thereafter. NOAA Fisheries asserts that averaging the flow throughout the migration season and comparing that average to the passage survival of various listed species over the season is an approach that provides a valid comparison for analytical purposes That is because the empirical flow-survival data used in the modeling analysis are also averaged over the passage season NOAA Fisheries uses seasonal average survival statistics to calibrate the SIMPAS model parameters, and the estimated seasonal average flows and spills under each scenario drive the model to estimate project and system survival rates for each listed species. NOAA Fisheries agrees that this modeling approach is not strongly predictive and is best suited to conduct relative survival comparisons between various fish passage and/or operational alternatives, which is how the model was used for the gap analysis.

NOAA Fisheries also received comments suggesting that additional water supplies for flow augmentation be included in the reference operation, specifically mentioning water that might be acquired from Canadian reservoirs, reservoirs owned and operated by Idaho Power Company,

[1] It is noteworthy that the range of water conditions experienced over the past 10 years in the Columbia Basin is representative of a full range of runoff conditions over the longer 50-year period.

and additional water from USBR reservoirs in the upper Snake River basin. Since all of these water sources are either outside the action area of this consultation or, in the case of the USBR reservoirs in the upper Snake Basin, are undergoing separate Section 7 consultation, additional flow augmentation water from those sources is not included in either the reference operation or the UPA.

2.1.2 Development of Average Spring Flows for the Proposed Hydro Operation

For the proposed hydro operation, Hydro staff used the description in the Updated Proposed Action (UPA) dated August 2004 from the Federal Action Agencies and their 2004-2008 Annual Implementation Plan for the 2000 Biological Opinion. Review of these documents suggests an operation that is similar to existing 2000 Biological Opinion operations. Accordingly, Hydro staff used current 2000 Biological Opinion operations to replicate the proposed action operation and relied on the seasonal average flows obtained from BPA's HYDSIM modeling of existing biological opinion operations over the 1929-1978 period to define the proposed action flow levels. The principle differences between this proposed hydro operation and the one analyzed in the 2000 Biological Opinion are updated Kootenai River white sturgeon and bull trout flow requirements consistent with the USFWS 2000 FCRPS Biological Opinion and changes in the maximum voluntary spill rates at several mainstem dams to reflect an improved understanding of spill effects on total dissolved gas. Again, average spring flows were obtained from the 50-year HYDSIM model output flows, using a post-processing hydrologic analysis. The seasonal average spring flows are shown in Table D.1 (see Attachment 1). The average spring flow targets from the 2000 Biological Opinion for the Snake and Columbia rivers were either met or exceeded, based on 50-year modeling of the proposed hydro operation, 68% and 82% of the time, respectively. In the reference operation, the spring flow targets from the 2000 Biological Opinion for the Snake and Columbia rivers were met or exceeded, based on 50-year modeling of the reference operation, 72% and 78% of the time, respectively.

Table D.1 – Average spring flows[2] (in kcfs) obtained from BPA hydrosystem modeling of both the proposed hydro action (P.A.) and reference operation (Ref.).

	Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
P.A.	L. Snake	56	93	125	146	105	112	80	54	85	73
P.A.	Columbia	162	245	316	402	259	311	246	156	257	196
Ref.	L. Snake	57	94	126	148	107	113	80	48	84	73
Ref.	Columbia	157	246	321	425	269	319	252	128	269	183

2.1.3 Spring Voluntary Fish Spill Levels for the Proposed Hydro and Reference Operations

For FCRPS project spill levels, Hydro staff assumed the following spring spill rates for each project under the proposed hydro operation (Table D.2). These levels are based on the Action

[2] Seasonal average flows during April 3-June 20 spring period at Lower Granite Dam on the lower Snake River and average flows during April 10-June 30 spring period at McNary Dam on the Columbia River. Flows shown are rounded to the nearest kcfs.

Agencies' UPA (November 2004). Table D.3 outlines the 24-hour spill levels that were defined by NOAA Fisheries in the reference operation.

Table D.2 – Proposed Hydro Operation Spring Spill Levels and Spill Caps

FCRPS dam-by-dam spill levels in kcfs (unless otherwise indicated)					
Dam	**Spill Cap-Night[3]**	**Spill Cap-Day**	**Spill Min**	**PH Min.**	**PH Max.**
LWG[4]	20	20	-	9	118
LGS	45	0	-	9	118
LMN	40	40	-	9	123
IHR[5]	20	20	-	9	92
MCN	150	0	-	50	170
JDA	60% or 160[6]	0	25%	50	350
TDA	40%	40%	-	50	345
BON	120	75	50	30	264

2.1.4 Spring Transportation Operations under the Proposed Hydro and Reference Operations

The Action Agencies' proposed Snake River spring juvenile transport operations incorporates recently compiled transport study results which includes the finding of Williams *et al.* (2004) who noted a lack of a consistent benefit provided from juvenile fish transport during much of April for wild juvenile SR spring chinook. Williams *et al.* (2004) stated that, "for wild yearling chinook salmon and steelhead, in almost all cases fish transported after 1 May returned at similar or higher rates than fish that migrated through the FCRPS reservoir and dams. In some years, fish transported as early as 15-20 April returned at higher rates than in-river fish, but not consistently." Based on these findings and similar findings reported by Anderson *et al*. (2004), the Action Agencies adopted April 20 as a date to commence transport operations at the three Snake River collector dams when spring seasonal average flow (April 3 – June 20) at Lower Granite dam is projected to exceed 70 kcfs. When seasonal average flow is forecasted to be less than 70 kcfs, all fish collected at the three Snake River collector dams would be transported.

Balancing the potential benefits of transportation with the possible risks this operation poses to long-term diversity of the ESU is challenging. Providing both spill and transportation is a method to balance the potential risks that might arise from relying solely on transportation as a management tool. Spill reduces the percentage of fish transported and increases the survival of the fish migrating in-river.

[3] Spill caps based on 120% allowable TDG in tailrace from fixed monitor station readings, unless otherwise noted (Lower Granite and Ice Harbor dams).
[4] Spill at Lower Granite is 20 kcfs total, which includes 7 kcfs through the RSW.
[5] Spill at Ice Harbor is 20 kcfs total, which includes 7 kcfs through the RSW.
[6] The John Day Dam spill cap is 60% of total river flow up to the gas cap of 160 kcfs. Then it becomes the gas cap.

Table D.3 – Reference Spring Operation Spill Levels, Spill Caps, and Assumptions.

Project	Reference Operation Spill Levels	Gas Cap Spill
Lower Granite	20 kcfs with RSW	60 kcfs
Little Goose	40 kcfs	45 kcfs
Lower Monumental	40 kcfs	40 kcfs
Ice Harbor	45 kcfs with RSW	100 kcfs
McNary	Spill to gas cap	185 kcfs
John Day	60% of project discharge up to gas cap	160 kcfs
The Dalles	40% of project discharge up to gas cap	150 kcfs
Bonneville	Day spill 120 kcfs; night spill up to gas cap	150 kcfs

Spill assumptions:

1. Gas cap spill based on 120% allowable TDG based on 2002 and 2003 tailrace fixed gas monitor station readings
2. 24-hour spill , unless noted
3. In-river fish passage priority
4. Voluntary spill
5. Adult passage factors considered

A description of the proposed action spring transport operation at the three lower Snake River collection projects follows: In years when the seasonal average Snake River flow at Lower Granite is expected to be under 70 kcfs, no spill would be provided and maximization of transportation will occur from the date the juvenile bypass systems begin operation. Due to the mixed benefits of early season transport, however, collection for transport will not be initiated until April 20 in all years where average seasonal flows are expected to equal or exceed 70 kcfs. Prior to April 20, all collected fish will be bypassed back to the river. In those years where flows are anticipated to be between 70 and 85 kcfs, spill will be provided at the collector projects until April 20. Further investigations into spill patterns (e.g. large gate openings/bulk spill) that provide optimum spillway survival conditions in these lower flow conditions will be coordinated through the FFDRWG The 70 kcfs seasonal threshold was chosen to reflect a breakpoint below which in-river survival is likely to decrease for spring juvenile migrants. When seasonal average flows are forecasted to be greater than 85 kcfs, spill will be provided at the three collector dams and fish would be collected and transported beginning on April 20. In addition, no collection or transportation will be provided for spring migrants from McNary Dam on the Columbia River in the proposed action.

The Action Agencies' proposed action transportation protocol at lower Snake River collector projects for spring juvenile migrants is summarized in the table below:

	< 70 kcfs	70-85 kcfs	> 85 kcfs
Transport	Maximize	Initiate Collection April 20	Initiate Collection April 20
Bypass	None	Bypass Through April 19	Bypass Through April 19
Spill	None	Spill Through April 20	Spill Through June 20

The spring transport operation specified in the reference operation is similar to the UPA proposal. The difference between the operations is the duration for which spill is provided at the lower Snake River collector projects in the 70 – 85 kcfs years and the fate of collected fish. The reference operation calls for spill until May 1 in these low flow years, and all collected fish are transported as opposed to being returned to the river. Similar to the UPA, the reference operation specified a full collection and transport operation, along with the curtailment of spill at Snake River collector dams, when the seasonal average flow projection was less than 70 kcfs. When seasonal average flows are forecasted to be greater than 85kcfs, the reference operation provides spill at the three collector dams and all fish collected would be transported. Similar to the proposed action, no collection or transportation of spring migrants will occur from McNary Dam.

The reference operation transportation protocol at lower Snake River collector projects for spring juvenile migrants is summarized in the table below:

	< 70 kcfs	70-85 kcfs	> 85 kcfs
Transport	Maximize	Initiate Collection April 1	Initiate Collection April 1
Bypass	None	None	None
Spill	None	Spill Through May 1	Spill Through June 20

The proposed action and reference operation represent two different approaches to managing the uncertainties of transportation for April migrants, particularly in the lower flow years. The proposed action addressed the uncertainty of transport by returning fish to the river in the April period and eliminating spill on April 20. The proposed action assures that if there were a transport benefit in late April, all fish would receive it. The reference operation acknowledged there is uncertainty associated with both returning fish to the river and transportation. These uncertainties are addressed by transporting all fish collected, and extending the time-frame during which fish are allowed passage by spill until May in lower flow years.

2.1.5 Development of Summer Flow Objectives for the Reference Operation

For the reference operation, the summer flow objectives for the Snake River were established as follows: June 21 through July 31, 65 kcfs; August 1 through August 31, 60 kcfs; and September 1 through September 15, 50 kcfs. These values are based on known flow/survival information (Smith *et al.* 2003), run timing, and historical water availability. That is, compared to spring flows, water available for summer flow augmentation in the Snake basin is limited. To maximize the potential benefit from available water, the highest flow objective was set for the June 21 through July 31 timeframe, when the majority of subyearling fall chinook are migrating, with flows gradually decreasing after that time. This approach also conforms more closely with the natural hydrograph, which typically peaks in June and then recedes throughout the summer.

Similarly, based on average run timing for SR fall chinook in the lower Columbia River, summer flow objectives in the reference operation were established as follows: July 1 through July 31, 210 kcfs; August 1 through September 7, 200 kcfs. The reference operation is based on full use of an unconstrained Federal hydropower system, which allows for a greater degree of operational flexibility than under the highly regulated regime that normally takes into account the combined constraints posed by the nondiscretionary project purposes of irrigation withdrawals, flood control, and hydropower operations.

To define a reference operation for SR fall chinook over the 8-year study period (1995-2001 and 2003), NOAA Fisheries staff again worked with BPA staff using BPA's hydro-system regulation model (HYDSIM) to evaluate changes in mainstem Snake and Columbia river summer flows and spills resulting from a reference operation under a full range of 50 different water years (1929-1978). This effort required numerous modeling changes and studies in trying to obtain the best reference operation, the priorities of which were to achieve refill of Federal storage projects by June 30, meet summer flow objectives, meet flow objectives in other periods of the year, and reduce involuntary spill at mainstem dams to minimize excess total dissolved gas. Average summer flows were obtained from the 50-year HYDSIM model output flows, using a post-processing hydrologic analysis. The flows are shown in Table D.4. See Attachment 1 for a description of how 1929-78 output summer period flows were matched to the biological opinion study period.

The average summer flow targets at Lower Granite and McNary dams for the reference operation were either met or exceeded, based on HYDSIM's 50-year hydro operations simulation, about 10% and 78% of the time, respectively.[7] In the reference operation, refill of Federal storage projects by about June 30 was achieved at Dworshak, Hungry Horse, Libby, and Grand Coulee 80%, 50%, 70%, and 100% of the time in the 50-year record, respectively.[8]

2.1.6 Development of Average Summer Flows for the Proposed Hydro Operation

For the proposed hydro operation flow objectives, NOAA Fisheries staff used the operations identified in the Federal Action Agencies' UPA, as well as their 2004-2008 Annual Implementation Plan for the 2000 Biological Opinion. These documents suggest a hydro operation with flow objectives that are similar to those specified in the 2000 Biological Opinion. NOAA Fisheries staff used current 2000 Biological Opinion operations to replicate the proposed hydro operations, in 2004, 2010, and 2014, and relied on the seasonal average flows obtained from BPA's HYDSIM modeling of existing biological opinion operations over the 1929-1978 period to define the proposed action flow levels. The principle differences between this proposed hydro operation and the one analyzed in the 2000 Biological Opinion are updated Kootenai River white sturgeon and bull trout flow requirements consistent with the USFWS 2000 FCRPS Biological Opinion and changes in the maximum voluntary spill rates at several mainstem dams to reflect an improved understanding of spill effects on total dissolved gas. Again, average

[7] Seasonal average flow targets used for this comparison were the same as those identified in the 2000 Biological Opinion.
[8] For the refill analysis, refill means the project is within 1-foot of full pool on or about June 30.

summer flows were obtained from the 50-year HYDSIM model output flows using a post-processing hydrologic analysis. The average summer flows are shown in Table D.4 (see Attachment 1). The average summer flow objectives from the 2000 Biological Opinion for Lower Granite and McNary dams were either met or exceeded, based on the 50-year proposed hydro operations modeling, 10% and 36% of the time, respectively. In the proposed hydro operation, refill by the end of June or early July was achieved at Dworshak, Hungry Horse, Libby, and Grand Coulee 82%, 56%, 26%, and 100% of the time in the 50-year record, respectively.[9]
Under the reference operation, the summer flow objectives at Lower Granite and McNary dams are achieved 10% and 78% of the years respectively. Under the reference operation, Dworshak would refill in 80% of the years, Hungry Horse would refill in 30% of the years, Libby would refill in 50% of the years, and Grand Coulee would refill in all years (100%).

Table D.4 – Simulated average summer flows[10] (in kcfs) obtained from BPA hydro-system modeling of both the proposed hydro action (P.A.) and reference operation (Ref.).

		1995	1996	1997	1998	1999	2000	2001	2003
P.A.	L. Snake	44	55	62	45	49	35	27	36
P.A.	L. Col.	139	190	198	136	184	132	115	129
Ref.	L. Snake	47	58	65	48	55	38	27	39
Ref.	L. Col.	179	214	220	178	210	178	166	175

2.1.7 Summer Voluntary Fish Spill Levels for the Proposed Hydro and Reference Operations

For FCRPS project spill levels under the proposed action, NOAA Fisheries staff used 2000 Biological Opinion summer spill rates for the proposed hydro operation (Table D.5). Table D.6 outlines the 24-hour spill levels that were defined for the reference operation.

2.1.8 Summer Transportation Operations under the Proposed Hydro and Reference Operations

It was assumed that summer transport operations under both the proposed hydro operation and the reference operation would be the same as defined in the 2000 Biological Opinion, i.e., no spill at collector projects and all collected fish to be transported from Lower Granite, Little Goose, Lower Monumental, and McNary dams.

[9] For the proposed operation refill analysis, refill means the project is within 1-foot of full pool or upper (flood control) rule curve on June 30. At Libby, refill events that occurred in July were included.
[10] Seasonal average flows during June 21 – September 30 summer period at Lower Granite Dam on the lower Snake River, and average flows during July 1 – September 30 summer period at McNary Dam on the Columbia River.

Table D.5 – Proposed Hydro Operation Summer Spill Levels and Spill Caps.

FCRPS dam-by-dam spill levels in kcfs unless otherwise indicated.					
Dam	**Spill Cap-Night**[11]	**Spill Cap-Day**	**Spill Min**	**PH Min.**	**PH Max.**
LWG	0	0	-	na	118
LGS	0	0	-	na	118
LMN	0	0	-	na	123
IHR[12]	20	20	-	9	92
MCN	0	0	-	na	170
JDA	30% or 160[13]	30% or 160	25%	50	350
TDA	40%	40%	-	50	345
BON	120	75	50	30	264

Table D.6 – Reference Operation Summer Spill Levels, Spill Caps and Assumptions.

Project	Reference Operation Spill Levels	Gas Cap Spill
Lower Granite	No spill	n/a
Little Goose	No spill	n/a
Lower Monumental	No spill	n/a
Ice Harbor	20 kcfs with RSW	100 kcfs
McNary	No spill	185 kcfs
John Day	60% of project discharge up to gas cap	160 kcfs
The Dalles	40% of project discharge up to gas cap	150 kcfs
Bonneville	Day spill 120 kcfs; night spill up to gas cap	150 kcfs

Spill assumptions:

1. Gas cap spill based on 120% allowable TDG based on 2002 and 2003 tailrace fixed gas monitor station readings
2. 24-hour spill , unless noted
3. Voluntary spill
4. Adult passage factors considered

[11] Spill caps based on 120% allowable TDG in tailrace from fixed monitor station readings, unless otherwise noted (Ice Harbor Dam).
[12] Spill at Ice Harbor is 20 kcfs total with RSW operation.
[13] The John Day Dam spill cap is 60% of total river flow up to the gas cap of 160 kcfs, when it becomes the gas cap.

Thus, for both operations, the summer transportation protocol for juvenile SR fall chinook salmon calls for the following actions:

- All fish collected at three Snake River collector dams and McNary Dam will be transported.

- Spill will not be provided during the summer period at the Snake River collector dams and McNary in order to maximize the number of fish collected and transported.

- Spill will be provided at non-collector dams, including Ice Harbor, John Day, The Dalles and Bonneville, on a 24-hour basis from approximately June 21 through August 31 for fish passage, but at different levels at some dams (Tables D.5 and D.6).

For the summer transport operations in the reference operation, NOAA Fisheries determined to continue the same transport operation as called for in the 2000 Biological Opinion. This is based on Williams *et al.* (2004), which states that "no empirical evidence exists to suggest that transportation either harms or helps fall chinook salmon." Thus, it is uncertain whether transport provides a benefit or a detriment for SR fall chinook. Given the uncertainty surrounding the effects of transportation for summer migrants, NOAA Fisheries exercised its best professional judgment in order to include transportation in the reference operation.

A significant consideration is that, for the past several years since the 2000 Biological Opinion, the region has experienced above-average adult returns of SR fall chinook under a strategy that maximizes transportation of juvenile SR fall chinook during the summer months. Without better information, a change to a strategy of leaving more fish in the river could either further improve or instead reduce the level of adult returns. The risk of a reduction in adult returns associated with leaving more fish in the river is less acceptable than the risk of failing to achieve even higher adult returns than the record numbers observed during the past four years.

Therefore, for the reference operation, NOAA Fisheries' transport strategy will be to use the same approach identified in the 2000 Biological Opinion, i.e., to maximize juvenile fish collection and transportation due to concerns about low in-river survival rates. However, given the absence of empirical information on the benefits of transportation for this stock, the Action Agencies' proposal to initiate an in-river survival and summer transport evaluation in the Snake River by 2007/2008 is an important component of this strategy.

Higher summer flows provided under the reference operation are intended to help move juvenile fish to the Snake River collector projects in a timely manner, as well as to improve in-river survival rates for those fish not transported (Williams *et al.* 2004). Even with the higher flows provided in the reference operation, average summer flows are often below the biological flow objectives (the Snake River flow objective is only met 10% of the time in the reference operation), and water temperatures can exceed the 20° C State of Washington water temperature standard in portions of the lower Snake River. Thus, under this transport strategy, fish spill continues to be curtailed at the four transport projects, and all collected fish are transported during the summer to try to improve overall juvenile fish survival. For those relatively few fish that remain in-river to migrate on their own, higher flows and 24-hour spill at each non-collector dam are provided in the reference operation to maximize in-river survival to below Bonneville Dam.

2.1.9 Summary Description of FCRPS Project Proposed Hydro and Reference Operations

Table D.7 provides a summary description of the differences in operations and system configuration, i.e., structural changes, between the proposed hydro operation and the reference operation[14] for FCRPS projects. Specific operations for ESA-listed bull trout and Kootenai River white sturgeon at Libby and Hungry Horse, with a related effect at Grand Coulee,[15] are included in both the proposed hydro operation and the reference operation, because those operations have already undergone ESA Section 7 consultation between the USFWS and the Action Agencies in 2000 and are included as part of the USFWS 2000 FCRPS Biological Opinion.

[14] The hypothetical reference operation serves an analytical purpose for the gap analysis but does not describe an operation that could actually be implemented, since the FCRPS projects must be operated to meet certain other authorized project purposes.

[15] Implementation of VARQ flood control operations at both Libby and Hungry Horse, which is required as part of the 2000 USFWS Biological Opinion for bull trout and sturgeon, results in a related minor change in flood control elevations at FDR Lake behind Grand Coulee Dam.

Table D.7 – Summary Description of the Reference and Proposed Hydro Operations and Fish Passage Improvements at FCRPS Projects

FCRPS Project	Reference Operation	Proposed Hydro Operation
Libby	• Operate as a run-of-river project, e.g., operate at full pool and pass inflow unless winter/spring drafts are needed for salmon flow augmentation or to reduce TDG downstream at mainstem dams. • Try to refill by about June 30 each year.[16] • Draft as needed to meet salmon flow targets and remove summer draft limit. • Draft limited to 346.0 ksfd (2325.8 ft.) in summer to ensure meeting project minimum flows. • Maintain minimum flows for ESA-listed bull trout. • Provide tiered volumes for ESA-listed KR white sturgeon spawning/recruitment. • Operate within hourly/daily ramp rates for bull trout. • Provide even or gradually declining flows during summer months (minimize double peak). • Negotiate with Canada annually to try to implement a storage exchange. • Limit spill to avoid exceeding Montana State TDG standards of 110%.	• Use VARQ flood control criteria. • Use variable Dec. 31 flood control curve based on runoff forecast. • Minimum flow = 4 kcfs. • Maintain minimum flows for bull trout. • Provide tiered volumes for listed KR white sturgeon spawning/recruitment. • Operate within hourly/daily ramp rates for bull trout. • Operate to achieve 75% chance of reaching URC elev. by April 10. • Refill by about June 30 each year. • Draft to meet salmon flow objectives during July-August with draft limit of 2439 ft. by Aug. 31. • Provide even or gradually declining flows during summer months (minimize double peak). • Negotiate with Canada annually to try to implement a storage exchange. • Limit spill to avoid exceeding Montana State TDG standards of 110%.
Hungry Horse	• Operate as a run-of-river project, e.g., operate at full pool and pass inflow unless winter/spring drafts are needed for salmon flow augmentation or to reduce TDG downstream at mainstem dams. • Try to refill by June 30 each year. • Draft as needed to meet salmon flow targets and remove summer draft limit. • Draft limited to 340.0 ksfd (3420.1 ft.) in summer to ensure reservoir refill. • Maintain minimum flows for ESA-listed bull trout. • Operate within hourly/daily ramp rates for bull trout. • Provide even or gradually declining flows during summer months (minimize double peak). • Limit spill to avoid exceeding Montana State TDG standards of 110%.	• Use VARQ flood control. • Min Q = 400-900 cfs at site, w/ sliding scale min Q of 3200-3500 cfs at Col. Falls. • Maintain minimum flows for bull trout. • Operate within hourly/daily ramp rates for bull trout. • Operate to achieve 75% chance of reaching URC elev. by April 10 • Refill by June 30 each year. • Draft to meet salmon flow objectives during July-August with draft limit of 3540 ft. by Aug. 31. • Provide even or gradually declining flows during summer months (minimize double peak). • Limit spill to avoid exceeding Montana State TDG standards of 110%.

[16] June 30 refill of FCRPS storage projects has priority over attempting to meet spring flow objectives.

FCRPS Project	Reference Operation	Proposed Hydro Operation
Albeni Falls	• Operate as a run-of-river project, e.g., operate at full pool and pass inflow unless winter/spring drafts are needed for salmon flow augmentation or to reduce TDG downstream at mainstem dams. • Draft to elev. 2051 ft. by Nov. 30 annually. • Try to refill by June 30. • Draft as needed to meet salmon flow targets.	• Use standard flood control. • Draft to elev. 2051 ft. by Nov. 30 annually.
Grand Coulee	• Operate as a run-of-river project, e.g., operate at full pool and pass inflow unless winter/spring drafts are needed for salmon flow augmentation or to reduce TDG downstream at mainstem dams. • Try to refill by June 30 each year. • Draft as needed to meet salmon flow targets and remove summer draft limits. • Eliminate irrigation withdrawal pumping into Banks Lake and remove associated return flows.	• Use standard flood control. • Operate to achieve 85% chance of reaching URC elevation by April 10. • Refill by June 30 each year. • Draft to meet salmon flow objectives during July-August with variable draft limit of 1278-1280 ft. by August 31. • Incl. irrigation withdrawal pumping into Banks Lake; operate Banks Lake up to 5 ft. from full pool during August to meet flow target.
Chief Joseph	• Use available storage to assist in meeting salmon flow targets. • Install spillway flow deflectors.	• Operate as run-of-river project. • Install spillway flow deflectors.
Dworshak	• Operate as a run-of-river project, e.g., operate at full pool and pass inflow unless winter/spring drafts are needed for salmon flow augmentation or to reduce TDG downstream at mainstem dams. • Draft as necessary to meet LWG flow objectives • Draft limited to 117.0 ksfd (1470 ft.) to improve the probability of refill. • Try to refill by June 30 each year. Draft as needed to meet salmon flow targets and regulate outflow temps. to achieve water temperature standard at LWG. • Maximum project discharge for salmon flow augmentation to be within State of Idaho TDG water quality standards (14 kcfs).	• Use standard flood control; shift system FC to GCL in below avg water years, if possible. • Minimum flow = 1.3 kcfs. • Refill by June 30 each year. • Draft to meet salmon flow objectives during July-August with draft limit of 1520 ft. by Aug. 31. • Regulate outflow temps to meet WQ temperature std. at LWG. • Maximum project discharge for salmon flow augmentation to be within State of Idaho TDG water quality standards (14 kcfs).

FCRPS Project	Reference Operation	Proposed Hydro Operation
Lower Snake River dams (LWG to IHR)	• Operate all projects at MOP elev. from April thru September. • During the spring: spill 20 kcfs at Lower Granite; spill 40 kcfs at Little Goose and Lower Monumental; spill 45 kcfs at Ice Harbor.[17] • During the summer: spill 20 kcfs at Ice Harbor; provide no spill at Lower Granite, Little Goose, and Lower Monumental.[18] • Transport all fish collected at LWG, LGS, and LMN in accordance with transport protocol described earlier . • Continue predator control. • Operate RSWs with 24-hour spill at Lower Granite (spring only) and Ice Harbor dams.	• Operate at MOP elev. from April 10 until small number of juvenile migrants are present, except at Lower Granite operate at MOP until TMT determines the Lower Granite forebay has cooled enough, generally after October 1. • During the spring: spill 20 kcfs at Ice Harbor and Lower Granite; spill to the gas cap at Little Goose and Lower Monumental.[19] • During the summer: spill 20 kcfs at Ice Harbor; provide no spill at Lower Granite, Little Goose, and Lower Monumental.[20] • Collect fish and transport at LWG, LGS and LMN; provide fish spill in years when flows >85 kcfs during spring months. • Operate RSWs with 24-hour spill at Lower Granite. Little Goose, Lower Monumental (in spring only) and at Ice Harbor Dam (when flows are ≥85 kcfs).
Columbia River dams (MCN to BON)	• Operate all projects at MOP elevations April through Sept. • Spill 120 kcfs during the day and spill to gas cap at night at Bonneville; spill 40% at The Dalles; spill 60% at John Day April thru Sept. 7. • Spill to the gas cap at McNary during the spring, and provide no spill at McNary during the summer. • Continue predator control. • Operate corner collector at Bonneville Second P.H. April through Sept. 7.	• Operate JDA pool at MIP from April 10 thru Sept. 30. • Spill 75 kcfs during the day and spill to the gas cap at night at Bonneville April through August. • Spill 40% at The Dalles April through August. • At John Day spill 60% at night during the spring (April-June) and 30% 24-hrs. during the summer (June-August). • At McNary, spill to the gas cap at night during the spring and provide no spill during the summer. • Operate corner collector at Bonneville Second P.H. April through August. • Operate RSWs with 24-hour spill at McNary (in spring only) and John Day dams.

[17] Spill levels at mainstem Snake and lower Columbia River FCRPS projects are defined in Tables 2, 3, 5 and 6.
[18] See Table 6.
[19] See Table 2.
[20] See Table 5.

2.1.10 Description of the Proposed Hydro and Reference Operations for Non-FCRPS Projects

No modification in current operations is assumed to be made for non-Federal hydropower projects. These projects are not a part of the FCRPS proposed action, but their operational effects are included in the hydrosystem modeling analysis of both the reference operation and the proposed action operation. Thus, the operation of non-Federal projects is, in essence, a common denominator in comparing the proposed action to the reference operation. Project operations for the non-Federal dams in the Columbia River basin are summarized below.

2.1.10.1 Canadian Projects

Operate all Canadian Columbia River Treaty projects to the appropriate Assured Operating Plan requirements. Operate Kootenai Lake to the current IJC order. Continue existing Treaty/Non-treaty non-power storage and flow shaping operations.

2.1.10.2 USBR Tributary Projects

One of the Action Agencies, the U.S. Bureau of Reclamation (USBR), is completing supplemental consultations on the operation and maintenance of its authorized tributary projects, the effects of which occur within the range of the listed species. To provide coverage on the entire effect of these tributary projects, USBR chose to consult on the mainstem effects of the 19 Columbia River Basin projects as part of the FCRPS consultation. The hydrologic effects calculated at the mouth of the tributary for each individual tributary consultation are assumed to be the hydrologic effects on the mainstem Columbia River for this consultation. Those effects can be found in Table 1-2 on page B-5 of Appendix B of the UPA (November 2004). A listing of the 19 USBR projects operating in the Columbia River Basin can be found in Table 1-1 on page B-2 of that document.

USBR projects in the upper Snake basin and the Idaho Power Company Hells Canyon Complex are not considered part of the environmental baseline for this analysis, because they are not within the FCRPS action area. There is currently a completed consultation on the upper Snake basin, so this analysis will use inflows to Brownlee based on the *2001 Amended Biological Assessment for Bureau of Reclamation Operations and Maintenance in the Snake River above Brownlee Reservoir* (USBR 2001). The ten upper Snake River projects that are listed in Table 1.0-1 on page 1-2 of the 2000 Biological Opinion have completed a Section 7(a)(2) consultation. The Lewiston Orchard project, also shown in Table 1.0-1, is undergoing separate consultation, and its effects are included in the 19 Columbia River projects mentioned previously.

3.0 THE GAP ANALYSIS

3.1 SR SPRING/SUMMER CHINOOK AND UCR AND LCR SPRING CHINOOK

Three major analytical steps were necessary under the NOAA Fisheries approach to complete a gap analysis using the SIMPAS model. The first step was to define and analyze a retrospective analysis of survivals over the 1994-2003 study period. This step is needed to determine if a relation between flow and survival existed during the study period and, if so, to define a functional relationship that could be applied to the reference and proposed hydro operation flow conditions. In this step, the SIMPAS model was calibrated to reflect the annual NWFSC empirical SR spring/summer chinook reach survival estimates using the actual flows, spills, and, to the extent possible, actual dam passage conditions and survival data applicable for each year.[21] The annual changes in various dam passage parameters for the yearling chinook retrospective analysis are specified in Tables D.8 through D.17. After calibrating the model with these annual reach survival data, the resultant pool survival estimates (empirical reach survival values without dam survival) were calculated by the model for use in the next step in the analysis.

[21] As part of the analytical approach for the retrospective analysis, NOAA Fisheries used actual seasonal average flow and project-specific spill levels that occurred in each year. Similarly, to reflect annual changes in dam survival, NOAA Fisheries used historical measured dam passage survival rates and fish passage efficiency data reflecting actual changes in passage conditions and/or installation of fish passage improvement facilities for each year and at each of the mainstem FCRPS dams.

Table D.8 -- 1994 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	18.6	1.5	68%	57% [6]	93%	98%	98%	n/a
LGS	15.3	12.0	68%	57%[6]	92%	100%[5]	99%	n/a
LMN	10.6	0.9	83%	49%	86.5%[4]	95.6%[7]	95%	n/a
IHR	23.1	18.1	50%	54%	90%	94%[8]	95%[10]	n/a
MCN	29.8	6.3	68%	57%[6]	90%	95%[11]	90%[11]	n/a
JDA	11.5	3.1	80%	73%	90%	98%	99%[14]	n/a
TDA	41.0	0.4	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I[9]				39%	90%		90%	90%[16]
Spillway	96.8	70.5	50%			98%		
BON-II				48%	90%		90%[17]	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation)
7. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
8. Average of 2000, '02, '03 IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
10. Best professional judgment given that the system passed fish through the sluiceway.
11. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with low spill.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Best professional judgment for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table D.9 --1995 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	19.0	3.2	68%	57%[6]	93%	98%	98%	n/a
LGS	29.2	10.1	68%	57%[6]	92%	100%[5]	99%	n/a
LMN	20.3	10.3	83%	49%	86.5%[4]	95.6%[8]	95%	n/a
IHR	34.5	35.5	50%	54%	90%	94%[9]	95%[10]	n/a
MCN	110.0	78.3	50%	57%[6]	90%	95%[11]	90%[11]	n/a
JDA	9.7	7.3	80%	73%	82%[12]	98%	95%[15]	n/a
TDA	124.2	124.2	50%	3%	84%[13]	90%[14]	n/a	96.5%[16]
BON-I [7]				39%	90%		90%	90%[17]
Spillway	110.5	73.0	50%			98%		
BON-II				48%	90%		90%[18]	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation)
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
9. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
10. Best professional judgment given that the system passed fish through the sluiceway.
11. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
12. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
13. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
14. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
15. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
16. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
17. Best professional judgment - assume no better than PH1 turbine survival.
18. Best professional judgment for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table D.10 -- 1996 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	55.4	51.3	50%	75%	93%	98%	98%	n/a
LGS	60.4	42.7	50%	78%	92%	100%[5]	99%	n/a
LMN	55.1	44.4	50%	49%	86.5%[4]	95.6%[8]	95%	n/a
IHR	58.6	55.8	50%	54%	90%	94%[9]	98%	n/a
MCN	206.8	199.9	50%	57%[6]	90%	95%[10]	90%[10]	n/a
JDA	85.7	79.6	50%	73%	82%[11]	98%	95%[14]	n/a
TDA	205.7	205.7	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				39%	90%		90%	90%[16]
Spillway	189.1	168.3	50%			98%		
BON-II				48%	90%		90%[17]	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation)
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
9. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
10. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
11. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Best judgment for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table D.11 -- 1997 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	60.9	47.8	50%	75%	93%	98%	98%	n/a
LGS	61.0	50.9	50%	78%	92%	100%[5]	99%	n/a
LMN	66.5	52.6	50%	49%	86.5%[4]	95.6%[6]	95%	n/a
IHR	90.3	83.7	50%	54%	90%	94%[8]	98%	n/a
MCN	266.5	263.0	50%	83%	90%	95%[9]	90%[9]	n/a
JDA	142.4	141.3	50%	73%	82%[10]	98%	95%[13]	n/a
TDA	267.3	267.3	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				39%	90%		90%	90%[15]
Spillway	234.7	226.2	50%			98%		
BON-II				48%	90%		90%[16]	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
15. Best professional judgment - assume no better than PH1 turbine survival.
16. Best judgment for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table D.12 -- 1998 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	37.2	30.4	50%	75%	93%	98%	98%	n/a
LGS	49.8	23.6	50%	78%	92%	100%[5]	99%	n/a
LMN	41.8	23.1	50%	49%	86.5%[4]	95.6%[6]	95%	n/a
IHR	80.5	52.3	50%	54%	90%	94%[8]	98%	n/a
MCN	139.3	93.5	50%	83%	90%	95%[9]	90%[9]	n/a
JDA	121.8	57.1	50%	73%	82%[10]	98%	95%[13]	n/a
TDA	126.1	126.1	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				39%	90%		90%	90%[15]
Spillway	129.1	91.0	50%			98%		
BON-II				48%	90%		90%[16]	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
15. Best professional judgment - assume no better than PH1 turbine survival.
16. Best judgment for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table D.13 --1999 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	63.4	24.1	68%	75%	93%	98%	98%	n/a
LGS	43.4	13.2	68%	78%	92%	100%[5]	99%	n/a
LMN	36	12.8	83%	49%	86.5%[4]	95.6%[6]	95%	n/a
IHR	91.1	53	50%	54%	90%	94%[8]	98%	n/a
MCN	140.2	128.1	50%	83%	90%	95%[9]	90%[9]	n/a
JDA	100.5	59.1	50%	73%	82%[10]	98%	95%[13]	n/a
TDA	129.3	129.3	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				39%	90%		90%	90%[15]
Spillway	119.7	93.2	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
15. Best professional judgment - assume no better than PH1 turbine survival.

Table D.14 -- 2000 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	33.2	16.2	68%	75%	93%	98%	98%	n/a
LGS	39.6	5.1	68%	78%	92%	100%[5]	99%	n/a
LMN	35.6	27.5	50%	49%	86.5%[4]	95.6%[6]	95%	n/a
IHR	81.6	45.6	50%	54%	90%	98%[8]	98%	n/a
MCN	123.7	70	50%	83%	90%	95%[9]	90%[9]	n/a
JDA	114.2	44.6	50%	73%	82%[10]	98%	95%[13]	n/a
TDA	93	93	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				39%	90%		90%	90%[15]
Spillway	98.7	85.1	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al. 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. IHR spillway survival based on 2000 PIT study (.978) - Eppard et al. 2002.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
15. Best professional judgment - assume no better than PH1 turbine survival.

Table D.15 --2001 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	0	0	68%	89%[4]	93%	98%	98%	n/a
LGS	0	0	68%	78%	92%	100%[6]	99%	n/a
LMN	0	2	83%	49%	86.5%[5]	95.6%[8]	95%	n/a
IHR	4	0.2	68%	68%[18]	90%	89%[9]	99%[18]	n/a
MCN	4	0.3	68%	83%	90%	95%[10]	90%[10]	n/a
JDA	9.9	0.6	80%	73%	82%[11]	98%	93%[14]	n/a
TDA	15.4	15.4	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				39%	92%[16]		90%	92%[17]
Spillway	18.4	17.9	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. 2002.
5. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
6. Iwamoto et al. 1994.
7. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
8. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al. 1995.
9. IHR spillway survival based on 2002 PIT study (.89) - Eppard et al. 2002.
10. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
11. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. 2001 R/T survival estimate for JDA JBS.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
16. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgment - assume no better than PH1 turbine survival.
18. Axel et al. 2001.

Table D.16 -- 2002 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	39.7	23.3	50%	75%	93%	95%[4]	98%	n/a
LGS	38.5	17.4	68%	78%	92%	100%[6]	99%	n/a
LMN	0.7	1	83%	49%	86.5%[5]	95.6%[8]	95%	n/a
IHR	72.3	43.2	50%	54%	90%	89%[9]	98%	n/a
MCN	153.2	85.6	50%	83%	90%	98%	93%[10]	n/a
JDA	115	59.2	50%	73%	82%[11]	98%	95%[14]	n/a
TDA	98.9	98.9	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				39%	92%[16]		90%	92%[17]
Spillway	135.1	115.1	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. LGR RSW evaluations, 2003.
5. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
6. Iwamoto et al. 1994.
7. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
8. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al. 1995.
9. IHR spillway survival based on 2002 PIT study (.892) - Eppard et al. 2002.
10. MCN bypass survival estimate from 2002 R/T survival study (Axel, G.A. et al. 2003).
11. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
16. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgment - assume no better than PH1 turbine survival.

Table D.17 -- 2003 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	39	18.2	50%	82%[4]	93%	95%[4]	98%	n/a	98%[4]
LGS	37.7	9.5	68%	78%	92%	100%[5]	99%	n/a	
LMN	29.2	30.5	50%	49%	86.5%[6]	90%[7]	95%	n/a	
IHR	59.8	45.4	50%	54%	89%[8]	95%[9]	98%	n/a	
MCN	115.1	42	50%	89%[10]	90%	93%[10]	86.5%[10]	n/a	
JDA	109.1	12.6	80%	73%	82%[11]	98%	95%[12]	n/a	
TDA	84.6	84.6	50%	0%	84%[13]	90%[14]	n/a	96.5%[15]	
BON-I[16]				39%	92%[17]		90%	92%[18]	
Spillway	132.4	105.9	50%			98%			
BON-II				48%	90%		98%	n/a	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. LGR RSW evaluations, 2003.
5. Iwamoto et al. 1994.
6. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
7. Hockersmith, E.E. et al. LMN spillway survival in 2003.
8. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
9. Eppard, et al. Survival of yearling chinook at IHR in 2003.
10. MCN bypass survival estimate from 2003 R/T survival study (Axel, G.A. et al. 2004).
11. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
13. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
14. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
16. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
17. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
18. Best professional judgment - assume no better than PH1 turbine survival.
19. RSW survival

Table D.18 shows the SR spring chinook individual pool survival estimates for each Lower Snake and Lower Columbia pool and dam reach for 1994 through 2003, as estimated using the SIMPAS model. The observed spring flows used for each major reach (Lower Snake [LSN] and Lower Columbia [LCO]) are listed at the bottom of the table. The more recent 1999 to 2003 pool survival estimates are based on empirical reach survival data for each reach, except the IHR, MCN, TDA, and BON reaches. Reach survivals for these four reaches were calculated based on the square root of a longer empirical reach that included two projects, i.e., LMN to MCN and JDA to BON. That is, equal survival was assumed through each pool (Sandford and Smith 2002). The 1994 to1998 data include some survival rates that were extrapolated from the upstream sampled reaches on a per-mile basis for the JDA (or TDA) through BON pools (as in the 2000 Biological Opinion, Appendix D). Because there are five years of survival estimates through all eight FCRPS projects, the per-mile survival expansion method could be compared with empirical survival estimates in these years. The expansion method tended to overestimate reach survival by about 1-3%, so correction factors were applied to all expanded reach survivals. The reaches start at the head of Lower Granite Pool and end at the tailrace of Bonneville Dam, and each project reach begins in the tailrace of the upstream dam and ends at the tailrace of the downstream dam.

Table D.18 – Per pool reach survivals by year, with **bolded values** based on empirical data:

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LWG	**0.9664**	**0.9293**	**1.0033**	**0.9391**	**0.9507**	**0.9660**	**0.9537**	**0.9860**	**0.9782**	**1.0191**
LGS	**0.8516**	**0.8951**	**0.9397**	**0.9551**	**1.0004**	**0.9636**	**0.9513**	**0.9696**	**0.9622**	**0.9588**
LMN	**0.9062**	**0.9679**	**0.9761**	**0.9418**	**0.8951**	**0.9703**	**0.9259**	**0.8880**	**1.0224**	**0.9575**
IHR	0.9028	**0.9635**	**0.8997**	**0.9227**	**0.9857**	**0.9792**	**1.0083**	**0.8921**	**0.9405**	**0.9773**
MCN	0.8782	**0.9623**	**0.8937**	**0.9162**	**0.9834**	**0.9774**	**0.9904**	**0.8707**	**0.9406**	**0.9781**
JDA	0.7691	0.8531	0.8498	0.8365	**0.8471**	**0.8795**	**0.9245**	**0.7909**	**0.9337**	**0.9193**
TDA	0.9083	0.9385	0.9374	0.9327	0.9444	**0.9902**	**0.9056**	**0.8703**	**1.0036**	**0.9903**
BON	0.8511	0.9048	0.9027	0.8943	0.9154	**0.9570**	**0.8762**	**0.8746**	**0.9716**	**0.9576**
Observed seasonal average flows for each reach:										
LSN	58	97	138	158	112	116	84	43	80	89
LCO	186	249	360	441	285	303	254	120	277	242

The second step in the analytical process was to determine if a relationship between flow and survival for each pool or for an entire reach existed and, if so, to describe it in the form of a functional relationship. Hydro staff regressed the lower Snake River and the lower Columbia reach survivals (single-pool survivals multiplied together to produce two 4-pool-reach survivals) from Table D.18 on seasonal average flows and a flow-survival relationship was developed (Attachment 3).

The final step was to apply the reach survival relationship to the seasonal average flows obtained from the hydrosystem modeling for both the proposed action and the reference operation. Using the developed flow-survival relationship, juvenile spring chinook reach survivals were calculated for both the reference operation flows and the proposed action flows for the lower Snake and lower Columbia reaches. The 4th root of the reach survivals was then calculated to obtain average single-pool survivals for each reach. Finally, the single-pool survivals for the reference operation were divided by the single-pool survivals of the proposed action operation to obtain an adjustment factor for use in estimating the reference operation pool survivals in the SIMPAS model for the gap analysis (Attachment 3).

In addition to changes in flows and spills between the reference and proposed action operations, certain dam passage parameters also changed between the two operations. For example, spill efficiency and diel passage parameters changed under different spill conditions or when changing from 12-hour spill in proposed hydro operation to 24-hour spill in the reference operation. The various dam passage parameters used in the survival gap analyses related to yearling chinook salmon for the reference operation and the 2004, 2010 and 2014 proposed hydro operations are shown on Tables D.19 through D.22.

For the gap analysis for UCR and LCR spring chinook salmon, Hydro staff assumed the juvenile survival rates for those species would be equivalent to the McNary-to-Bonneville dam survival rates of SR spring/summer chinook salmon, including the flow-survival relationship.

3.2 SR, UCR, MCR, AND LCR STEELHEAD

As with SR spring chinook, the same three analytical steps were taken to complete a gap analysis for SR steelhead using the SIMPAS model. The first step was to define and analyze a retrospective analysis of survivals over the 1994-2003 study period. This step is needed to determine if a relation between flow and survival existed during this time period and, if so, to define a functional relationship that could be applied to the reference and proposed action flow conditions. In this step, the SIMPAS model was set up to reflect the annual NWFSC empirical SR steelhead reach survival estimates using the actual flows, spills, and, to the extent possible, actual dam passage conditions and survival data applicable for each year. The annual changes in various dam passage parameters for the steelhead retrospective analysis are specified in Tables D.23 through D.32. After calibrating the model to these annual data, the resulting pool survival estimates (empirical reach survival values without dam survival) were calculated by the model for use in the next step in the analysis.

Table D.19 -- Proposed 2004 Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	82%[3]	n/a	93%	98%	98%	n/a	98%[3]
LGS	50/68%	78%	n/a	92%	100%[4]	99%	n/a	
LMN	50/83%	49%	n/a	86.5%[5]	95.6%[6]	95%	n/a	
IHR	50/68%	78%[20]	n/a	89%[7]	96%[7]	98%	n/a	98%[4]
MCN	50/68%	89%[9]	n/a	90%	95%[8]	90%[8]	n/a	
JDA	50/80%	73%	n/a	82%[8]	98%	95%[10]	n/a	
TDA	50%	n/a	equ[18]	84%[11]	96%[12]	n/a	96.5%[13]	
BON-I		n/a	equ[18]	92%[15]		n/a	92%[16]	
Spillway	50%				98%			
BON-II[14]		48%	46%[17]	90%		98%	98%[19]	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Diels for very low spills are based on 2000 Biological Opinion, Appendix page D-13. Diel is 50% for significant 24 hour spills.
3. RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. 1993 spring chinook PIT study, Iwamoto et al. 1994.
5. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
6. LMN spill survival - average of '94 survival estimates (.927, .984). Muir et al. 1995
7. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
9. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
10. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Best professional judgment given installation of spillway divider wall in 2003.
13. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
14. Bonneville Powerhouse priority is PH2.
15. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Best professional judgment based on limited 1999 sluiceway studies.
18. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
19. BON sluiceway survival based on best professional judgment.
20. Brege et al. 1988.

Table D.20 -- Reference Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Diel Passage[3]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	82%[3]	n/a	93%	98%	98%	n/a	98%[3]
LGS	50/68%	78%	n/a	92%	100%[4]	99%	n/a	
LMN	50/83%	49%	n/a	86.5%[5]	95.6%[6]	95%	n/a	
IHR	50/68%	78%[20]	n/a	89%[7]	96%[7]	98%	n/a	98%[4]
MCN	50/68%	89%[9]	n/a	90%	95%[8]	90%[8]	n/a	
JDA	50/80%	73%	n/a	82%[9]	98%	95%[10]	n/a	
TDA	50%	n/a	equ[18]	84%[11]	96%[12]	n/a	96.5%[13]	
BON-I		n/a	equ[18]	92%[15]		n/a	92%[16]	
Spillway	50%				98%			
BON-II[14]		48%	46%[17]	90%		98%	98%[19]	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Diels for very low spills are based on 2000 Biological Opinion, Appendix page D-13. Diel is 50% for significant 24 hour spills.
3. RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. 1993 spring chinook PIT study, Iwamoto et al. 1994.
5. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
6. LMN spill survival - average of '94 survival estimates (.927, .984). Muir et al. 1995
7. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
9. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
10. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Best professional judgment given installation of spillway divider wall in 2003.
13. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
14. Bonneville Powerhouse priority is PH2.
15. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Best professional judgment based on limited 1999 sluiceway studies.
18. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
19. BON sluiceway survival based on best professional judgment.
20. Brege et al. 1988.

Table D.21 -- Proposed 2010 Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Diel Passage	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival[4]
LGR	50/68%	82%	n/a	94%[2]	98%	98%	n/a	98%
LGS	50/68%	78%	n/a	92%	100%	99%	n/a	
LMN	50/83%	49%	n/a	86.5%	95.6%	95%	n/a	98%
IHR	50/68%	78%[12]	n/a	89%	98%[5]	98%	n/a	98%
MCN	50/68%	89%	n/a	91%[2]	96%[6]	93%[7]	n/a	98%
JDA	50/80%	73%	n/a	85%[3]	98%	97%[8]	n/a	
TDA	50%	n/a	equ	84%	98%[9]	n/a	96.5%	
BON-I		n/a	equ	92%		n/a	92%	
Spillway	50%				98%			
BON-II		54%[10]	40%[11]	90%		98%	98%	

References:

1. All parameters without specific references are the same as the 2004 Proposed Operation.
2. Future turbine survivals were increased 1 to 2% based on improved turbine operations (and design in some cases).
3. JDA 3% turbine survival increased based on improved powerhouse egress conditions.
4. RSW survivals and efficiencies are based on LGR studies, assumed MCN operated at same % RSW flows as LGR.
5. IHR spillway survival increase of 2% due to future stilling basin mods.
6. MCN spillway survival increased 1% due to improved egress conditions.
7. MCN bypass survival increased 2% due to outfall relocation and improved egress.
8. JDA bypass survival increased 2% due to improved egress.
9. TDA spill survival, 1% increase due to spill basin improvements and 1% due to egress improvements.
10. BON PH2 FGE increased 6% due to FGE improvement program (based on est. 12% increase for half the units).
11. Sluice chute guidance decreased 6% based on preliminary 2004 sluice chute studies.
12. Brege et al. 1988.

Table D.22 -- Proposed 2014 Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Diel Passage	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	82%	n/a	94%	98%	98%	n/a	98%
LGS	50/68%	78%	n/a	93%[2]	100%	99%	n/a	
LMN	50/83%	49%	n/a	87.5%[2]	98%[3]	95%	n/a	98%
IHR	50/68%	78%	n/a	91%[2]	98%	98%	n/a	98%
MCN	50/68%	89%	n/a	92%[2]	96%	93%	n/a	98%
JDA	50/80%	80%[9]	n/a	85%	98%	97%	n/a	
TDA	50%	50%[6]	equ	84%	98%	n/a	98%[4]	
BON-I		72%[7]	equ	92%		98%[8]	98%[4]	
Spillway	50%				98%			
BON-II		60%[5]	40%	90%		98%	98%	

References:

1. All parameters without specific references are the same as the 2010 Proposed Operation.
2. Future turbine survivals were increased 1 to 2%based on improved turbine operations (and design in some cases).
3. LMN spillway survival increase 2.5% due to deflector mods and improved tailrace egress.
4. Sluiceway survival increased 1.5 and 6% for TDA and BON, respectively, due to relocation of outfalls.
5. BON PH2 FGE increased 6% due to completion of the FGE improvement program.
6. TDA FGE is added to simulate increased sluiceway efficiency - turbine entrainment is cut in half (under a 40% spill condition)
7. BON PI FGE based on Bonneville Decision Document.
8. BON PI bypass survival same as BON PII bypass survival (same outfall).
9. JDA FGE based on 1996, '99 and '02 FGE studies.

Table D.23 -- 1994 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	18.6	1.5	76%	57%[6]	93%	98%	98%	n/a
LGS	15.3	12.0	76%	57%[6]	92%	100%[5]	95%	n/a
LMN	10.6	0.9	83%	82%	86.5%[4]	95.6%[7]	93%	n/a
IHR	23.1	18.1	50%	93%	90%	94%[8]	95%[10]	n/a
MCN	29.8	6.3	76%	57%[6]	90%	95%[11]	90%[11]	n/a
JDA	11.5	3.1	83%	85%	90%	93%[18]	92%[14]	n/a
TDA	41.0	0.4	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I[9]				41%	90%		90%	90%[16]
Spillway	96.8	70.5	50%			98%		
BON-II				48%	90%		90%[17]	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation)
7. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
8. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
9. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
10. Best professional judgment given that the system passed fish through the sluiceway.
11. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2003, 2004)
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Point estimate for JDA JBS RT steelhead survival in 2001 with low spill.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Best professional judgment for PH2 JBS spring migrants given poor summer results and PH1 flow priority.
18. Point estimate for steelhead route specific spill survival with lower spill levels in 2002.

Table D.24 -- 1995 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	19.0	3.2	76%	57%[6]	93%	98%	98%	n/a
LGS	29.2	10.1	76%	57%[6]	92%	100%[5]	95%	n/a
LMN	20.3	10.3	83%	82%	86.5%[4]	95.6%[8]	93%	n/a
IHR	34.5	35.5	50%	93%	90%	94%[9]	95%[10]	n/a
MCN	110.0	78.3	50%	57%[6]	90%	95%[11]	90%[11]	n/a
JDA	9.7	7.3	83%	85%	82%[12]	93%[19]	95%[15]	n/a
TDA	124.2	124.2	50%	3%	84%[13]	90%[14]	n/a	96.5%[16]
BON-I [7]				41%	90%		90%	90%[17]
Spillway	110.5	73.0	50%			98%		
BON-II				48%	90%		90%[18]	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation)
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
9. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
10. Best professional judgment given that the system passed fish through the sluiceway.
11. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2003, 2004)
12. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
13. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
14. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
15. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
16. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
17. Best professional judgment - assume no better than PH1 turbine survival.
18. Best professional judgment for PH2 JBS spring migrants given poor summer results and PH1 flow priority.
19. Point estimate for steelhead route specific spill survival with lower spill levels in 2002.

Table D.25 -- 1996 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	55.4	51.3	50%	81%	93%	98%	98%	n/a
LGS	60.4	42.7	50%	81%	92%	100%[5]	95%	n/a
LMN	55.1	44.4	50%	82%	86.5%[4]	95.6%[8]	93%	n/a
IHR	58.6	55.8	50%	93%	90%	94%[9]	98%	n/a
MCN	206.8	199.9	50%	57%[6]	90%	95%[10]	90%[10]	n/a
JDA	85.7	79.6	50%	85%	82%[11]	96%[18]	95%[14]	n/a
TDA	205.7	205.7	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				41%	90%		90%	90%[16]
Spillway	189.1	168.3	50%			98%		
BON-II				48%	90%		90%[17]	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation)
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
9. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
10. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2003, 2004)
11. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Best judgment for PH2 JBS spring migrants given poor summer results and PH1 flow priority.
18. Point estimate for steelhead route specific spill survival with 60% spill level in 2002.

Table D.26 -- 1997 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	60.9	47.8	50%	81%	93%	98%	98%	n/a
LGS	61.0	50.9	50%	81%	92%	100%[5]	95%	n/a
LMN	66.5	52.6	50%	82%	86.5%[4]	95.6%[6]	93%	n/a
IHR	90.3	83.7	50%	93%	90%	94%[8]	98%	n/a
MCN	266.5	263.0	50%	89%	90%	95%[9]	90%[9]	n/a
JDA	142.4	141.3	50%	85%	82%[10]	98%	95%[13]	n/a
TDA	267.3	267.3	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				41%	90%		90%	90%[15]
Spillway	234.7	226.2	50%			98%		
BON-II				48%	90%		90%[16]	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
9. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
15. Best professional judgment - assume no better than PH1 turbine survival.
16. Best judgment for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table D.27 -- 1998 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	37.2	30.4	50%	81%	93%	98%	98%	n/a
LGS	49.8	23.6	50%	81%	92%	100%[5]	95%	n/a
LMN	41.8	23.1	50%	82%	86.5%[4]	95.6%[6]	93%	n/a
IHR	80.5	52.3	50%	93%	90%	94%[8]	98%	n/a
MCN	139.3	93.5	50%	89%	90%	95%[9]	90%[9]	n/a
JDA	121.8	57.1	50%	85%	82%[10]	98%	95%[13]	n/a
TDA	126.1	126.1	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				41%	90%		90%	90%[15]
Spillway	129.1	91.0	50%			98%		
BON-II				48%	90%		90%[16]	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
9. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
15. Best professional judgment - assume no better than PH1 turbine survival.
16. Best judgment for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table D.28 -- 1999 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	63.4	24.1	76%	81%	93%	98%	98%	n/a
LGS	43.4	13.2	76%	81%	92%	100%[5]	95%	n/a
LMN	36	12.8	83%	82%	86.5%[4]	95.6%[6]	93%	n/a
IHR	91.1	53	50%	93%	90%	94%[8]	98%	n/a
MCN	140.2	128.1	50%	89%	90%	95%[9]	90%[9]	n/a
JDA	100.5	59.1	50%	85%	82%[10]	98%	95%[13]	n/a
TDA	129.3	129.3	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				41%	90%		90%	90%[15]
Spillway	119.7	93.2	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
9. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
15. Best professional judgment - assume no better than PH1 turbine survival.

Table D.29 -- 2000 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	33.2	16.2	76%	81%	93%	98%	98%	n/a
LGS	39.6	5.1	76%	81%	92%	100%[5]	95%	n/a
LMN	35.6	27.5	50%	82%	86.5%[4]	95.6%[6]	93%	n/a
IHR	81.6	45.6	50%	93%	90%	98%[8]	98%	n/a
MCN	123.7	70	50%	89%	90%	95%[9]	90%[9]	n/a
JDA	114.2	44.6	50%	85%	82%[10]	98%	95%[13]	n/a
TDA	93	93	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				41%	90%		90%	90%[15]
Spillway	98.7	85.1	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir et. al. N. Am J. of Fish Mgmt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. IHR spillway survival based on 2000 PIT yearling chinook study (.978) - Eppard et al. 2002.
9. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
15. Best professional judgment - assume no better than PH1 turbine survival.

Table D.30 -- 2001 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	0	0	76%	89%[4]	93%	98%	98%	n/a
LGS	0	0	76%	81%	92%	100%[6]	95%	n/a
LMN	0	2	83%	82%	86.5%[5]	95.6%[8]	93%	n/a
IHR	4	0.2	50%	93%	90%	89%[9]	99%[18]	n/a
MCN	4	0.3	76%	89%	90%	95%[10]	90%[10]	n/a
JDA	9.9	0.6	83%	85%	82%[11]	98%	92%[14]	n/a
TDA	15.4	15.4	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				41%	92%[16]		90%	92%[17]
Spillway	18.4	17.9	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. 2002.
5. Muir et. Al. N. Am J. of Fish Mgmt. 2001.
6. Iwamoto et al. 1994.
7. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
8. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
9. IHR spillway survival based on 2002 PIT yearling chinook study (.89) - Eppard et al. 2002.
10. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2003, 2004)
11. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Point estimate for JDA JBS RT steelhead survival in 2001 with low spill.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
16. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgment - assume no better than PH1 turbine survival.
18. Axel et al. 2001.

Table D.31 -- 2002 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	39.7	23.3	50%	81%	93%	95%[4]	98%	n/a
LGS	38.5	17.4	76%	81%	92%	100%[6]	95%	n/a
LMN	0.7	1	83%	82%	86.5%[5]	95.6%[8]	93%	n/a
IHR	72.3	43.2	50%	93%	90%	89%[9]	98%	n/a
MCN	153.2	85.6	50%	89%	90%	98%	93%[10]	n/a
JDA	115	59.2	50%	85%	82%[11]	98%	95%[14]	n/a
TDA	98.9	98.9	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				41%	92%[16]		90%	92%[17]
Spillway	135.1	115.1	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. LGR RSW evaluations, 2003.
5. Muir et. al. N. Am J. of Fish Mgmt. 2001.
6. Iwamoto et al. 1994.
7. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
8. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
9. IHR spillway survival based on 2002 PIT yearling chinook study (.89) - Eppard et al. 2002.
10. MCN bypass survival estimate from 2002 R/T spring chinook survival study (Axel, G.A. et al. 2003, 2004)
11. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Average of point estimates for route specific JDA JBS yrlg chinook survival in 2002 and 2003 with 0/60 spill (91 and 100%).
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
16. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgment - assume no better than PH1 turbine survival.

Table D.32 -- 2003 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	39	18.2	50%	81%	93%	95%[4]	98%	n/a	98%[4]
LGS	37.7	9.5	76%	81%	92%	100%[5]	95%	n/a	
LMN	29.2	30.5	50%	82%	86.5%[6]	90%[7]	93%	n/a	
IHR	59.8	45.4	50%	93%	89%[8]	95%[9]	98%	n/a	
MCN	115.1	42	50%	89%	90%	93%[10]	86.5%[10]	n/a	
JDA	109.1	12.6	83%	85%	82%[11]	98%	95%[12]	n/a	
TDA	84.6	84.6	50%	3%	84%[13]	90%[14]	n/a	96.5%[15]	
BON-I[16]				41%	92%[17]		90%	92%[18]	
Spillway	132.4	105.9	50%			98%			
BON-II				48%	90%		98%	n/a	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. LGR RSW evaluations, 2003.
5. Iwamoto et al. 1994.
6. Muir et. al. N. Am J. of Fish Mgmt. 2001.
7. Hockersmith, E.E. et al. LMN spillway yearling chinook survival in 2003.
8. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
9. Eppard, et al. Survival of yearling chinook at IHR in 2003.
10. MCN bypass survival estimate from 2003 R/T spring chinook survival study (Axel, G.A. et al. 2003, 2004)
11. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. Average of point estimates for route specific JDA JBS yrlg chinook survival in 2002 and 2003 with 0/60 spill (91 and 100%).
13. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
14. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
16. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
17. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
18. Best professional judgment - assume no better than PH1 turbine survival.

Table D.33 shows the SR steelhead individual pool survival estimates for each lower Snake and lower Columbia pool and dam reach for 1994 through 2003, as estimated using the SIMPAS model. The observed spring flows used for each major reach (lower Snake [LSN] and lower Columbia [LCO]) are listed at the bottom of the table. The more recent 1999 to 2003 pool survival estimates are based on empirical reach survival data for each reach, except the IHR, MCN, TDA, and BON reaches. Reach survivals for these four reaches were calculated based on the square root of a longer empirical reach that included two projects, i.e., LMN to MCN and JDA to BON. That is, equal survival was assumed through each pool (Sandford and Smith 2002). The 1994 to1998 data include some survival rates that were extrapolated from the upstream sampled reaches on a per-mile basis for the JDA (or TDA) through BON pools (as described in the 2000 Biological Opinion, Appendix D). Because there are five years of survival estimates through all eight FCRPS projects, per-mile survival expansions could be compared with empirical survival estimates in those years. The expansion method appeared to miscalculate reach survival by about 1- 4%, so correction factors were applied to all expanded reach survivals. The reaches start at the head of Lower Granite Pool and end at the tailrace of Bonneville Dam, and each project reach extends from the tailrace of the upstream dam to the tailrace of the downstream dam.

Table D.33 – Per pool reach survivals by year, with **bolded values** based on empirical data:

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LWG	0.9125	**0.9781**	**0.9570**	**0.9880**	**0.9475**	**0.9301**	**0.9881**	**0.9348**	**0.9345**	**0.9600**
LGS	**0.8754**	**0.9346**	**0.9589**	**0.9909**	**0.9523**	**0.9524**	**0.9244**	**0.8482**	**0.9027**	**0.9754**
LMN	**0.9465**	**1.0000**	**0.9839**	**0.9473**	**0.9349**	**0.9661**	**0.9498**	**0.7621**	**0.9478**	**0.9448**
IHR	1.0000	**0.9601**	**0.9198**	**0.9417**	**0.9191**	**0.9397**	**0.9433**	**0.5533**	**0.8959**	**0.8881**
MCN	0.9981	**0.9611**	**0.9175**	**0.9345**	**0.9144**	**0.9348**	**0.9403**	**0.5601**	**0.8271**	**0.8628**
JDA	0.9558	0.9094	0.8692	0.8835	**0.8538**	**0.9460**	**0.8742**	**0.3478**	**0.8673**	**0.9032**
TDA	0.8931	0.9466	0.9332	0.9380	**1.0000**	**0.8918**	**0.9143**	**0.9829**	**0.8237**	**0.8358**
BON	0.8411	0.9897	0.9637	0.9730	**1.0000**	**0.8747**	**0.9206**	**0.9371**	**0.8254**	**0.8375**
Observed seasonal average flows for each reach:										
LSN	58	97	138	158	112	116	84	43	80	89
LCO	186	249	360	441	285	303	254	120	277	242

The second step in the analytical process was to determine if a relationship between flow and survival for each pool or for an entire reach existed and, if so, to describe it in the form of a functional relationship. Hydro Division staff regressed the lower Snake River and the lower Columbia reach survivals (single-pool survivals multiplied together to produce two 4-pool-reach survivals) from Table D.33 on seasonal average flows, and a flow-survival relationship was developed (Attachment 3).

The final step was to apply the reach survival relationship to the seasonal average flows obtained from BPA's hydro-system modeling for both the proposed action and the reference operation. Using the developed flow-survival relationship, juvenile steelhead reach survivals were calculated for both the reference operation flows and the proposed hydro operation flows for the lower Snake and lower Columbia reaches. The 4th root of the reach survivals was then calculated to obtain average single-pool survivals for each reach. Finally, the single-pool survivals for the reference operation were divided by the single-pool survivals of the proposed hydro operation to obtain an adjustment factor for use in estimating the reference operation pool survivals in the SIMPAS model for the gap analysis.

In addition to changes in flows and spills between the reference and proposed hydro operations, certain dam passage parameters also changed between the two operations. For example, spill efficiency and diel passage parameters changed under different spill conditions or when changing from 12-hour spill in proposed hydro operation to 24-hour spill in the reference operation. The various dam passage parameters used in the survival gap analyses related to steelhead for the reference operation and the 2004, 2010 and 2014 proposed hydro operations are shown on Tables D.34 through D.37.

For the gap analysis for UCR, MCR, and LCR steelhead, NOAA Fisheries assumed the juvenile survival rates for those species would be equivalent to the respective McNary to Bonneville Dam survival rates of SR steelhead, including the flow-survival relationship.

3.3 SR AND LCR FALL CHINOOK

As with SR spring chinook and SR steelhead, the same three analytical steps were necessary to complete a gap analysis for SR fall chinook using the SIMPAS model. A retrospective analysis of survivals over the 1995-2003 study period (not including 2002, due to lack of available healthy research fish) was defined and analyzed in the first step. This step is needed to determine if a relation between flow and survival existed during the study period and, if so, to define a functional relationship that could be applied to the reference and proposed action flow conditions. In this step, the SIMPAS model was set up to reflect the annual empirical SR fall chinook reach survival estimates using the actual flows, spills, and, to the extent possible, actual dam passage conditions and survival data applicable for each year. The annual changes in various dam passage parameters for the fall chinook retrospective analysis are specified in Tables D.38 through D.45. After setting up the model with these annual data, the resulting pool survival estimates (empirical reach survival values without dam survival) were calculated by the model for use in the next step in the analysis.

Table D.34 -- Proposed 2004 Operation Passage Parameters for Snake River Steelhead[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/76%	81%	n/a	93%	98%	98%	n/a	98%[3]
LGS	50/76%	81%	n/a	92%	98.5%[4]	95%	n/a	
LMN	50/83%	82%	n/a	86.5%[5]	95.6%[6]	93%	n/a	
IHR	50/76%	93%	n/a	89%[7]	96%[7]	98%	n/a	98%[3]
MCN	50/76%	89%	n/a	90%	95%[8]	90%[8]	n/a	
JDA	50/83%	85%	n/a	82%[9]	98%	95%[10]	n/a	
TDA	50%	n/a	equ[18]	84%[11]	96%[12]	n/a	96.5%[13]	
BON-I		n/a	equ[18]	92%[15]		n/a	92%[16]	
Spillway	50%				98%			
BON-II[15]		48%	62%[17]	90%		98%	98%[19]	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
3. RSW survival from 2003 LGR RT yrlg chinook studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. 1997 PIT steelhead study at LGS (average of .97 and 1.0) - Muir et al. 1998.
5. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
6. LMN spill survival - average of '94 spring chinook survival estimates (.927, .984). Muir et al. 1995
7. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
9. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
10. Average of point estimates for route specific JDA JBS yrlg chinook survival in 2002 and 2003 with 0/60 spill (91 and 100%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Best professional judgment given installation of spillway divider wall in 2003.
13. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
14. Bonneville Powerhouse priority is PH2.
15. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Best professional judgment based on limited 1999 sluiceway studies.
18. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
19. BON sluiceway survival based on best professional judgment.

Table D.35 -- Reference Operation Passage Parameters for Snake River Steelhead[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/76%	81%	n/a	93%	98%	98%	n/a	98%[3]
LGS	50/76%	81%	n/a	92%	98.5%[4]	95%	n/a	
LMN	50/83%	82%	n/a	86.5%[5]	95.6%[6]	93%	n/a	
IHR	50/76%	93%	n/a	89%[7]	96%[7]	98%	n/a	98%[3]
MCN	50/76%	89%	n/a	90%	95%[8]	90%[8]	n/a	
JDA	50/83%	85%	n/a	82%[9]	98%	95%[10]	n/a	
TDA	50%	n/a	equ[18]	84%[11]	96%[12]	n/a	96.5%[13]	
BON-I		n/a	equ[18]	92%[15]		n/a	92%[16]	
Spillway	50%				98%			
BON-II[15]		48%	62%[17]	90%		98%	98%[19]	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
3. RSW survival from 2003 LGR RT yrlg chinook studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. 1997 PIT steelhead study at LGS (average of .97 and 1.0) - Muir et al. 1998.
5. Muir, et. al. N. Am J. of Fish Mgmt. 2001.
6. LMN spill survival - average of '94 spring chinook survival estimates (.927, .984). Muir et al. 1995
7. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
9. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
10. Average of point estimates for route specific JDA JBS yrlg chinook survival in 2002 and 2003 with 0/60 spill (91 and 100%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Best professional judgment given installation of spillway divider wall in 2003.
13. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
14. Bonneville Powerhouse priority is PH2.
15. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Best professional judgment based on limited 1999 sluiceway studies.
18. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
19. BON sluiceway survival based on best professional judgment.

Table D.36 --Proposed 2010 Operation Passage Parameters for Snake River Steelhead[1]

Project	Diel Passage	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival[4]
LGR	50/76%	81%	n/a	94%[2]	98%	98%	n/a	98%
LGS	50/76%	81%	n/a	92%	98.5%	95%	n/a	
LMN	50/83%	82%	n/a	86.5%	95.6%	93%	n/a	98%
IHR	50/76%	93%	n/a	89%	98%[5]	98%	n/a	98%
MCN	50/76%	89%	n/a	91%[2]	96%[6]	93%[7]	n/a	98%
JDA	50/83%	85%	n/a	85%[3]	98%	97%[8]	n/a	
TDA	50%	n/a	equ	84%	98%[9]	n/a	96.5%	
BON-I		n/a	equ	92%		n/a	92%	
Spillway	50%				98%			
BON-II		54%[10]	70%[11]	90%		98%	98%	

References:

1. All parameters without specific references are the same as the 2004 Proposed Operation.
2. Future turbine survivals were increased 1 to 2%based on improved turbine operations (and design in some cases).
3. JDA 3% turbine survival increased based on improved powerhouse egress conditions.
4. RSW survivals and efficiencies are based on LGR studies, assumed MCN operated at same % RSW flows as LGR.
5. IHR spillway survival increase of 2% due to future stilling basin mods.
6. MCN spillway survival increased 1% due to improved egress conditions.
7. MCN bypass survival increased 2% due to outfall relocation and improved egress.
8. JDA bypass survival increased 2% due to improved egress.
9. TDA spill survival, 1% increase due to spill basin improvements and 1% due to egress improvements.
10. BON PH2 FGE increased 12% due to FGE improvement program.
11. Sluice chute guidance increased 8% based on preliminary 2004 sluice chute studies.

Table D.37 -- Proposed 2014 Operation Passage Parameters for Snake River Steelhead[1]

Project	Diel Passage	FGE	SLPE	Turbine Survival[2]	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival[4]
LGR	50/76%	81%	n/a	94%	93%	98%	n/a	98%
LGS	50/76%	81%	n/a	93%[2]	98.5%	95%	n/a	
LMN	50/83%	82%	n/a	87.5%[2]	98%[3]	93%	n/a	98%
IHR	50/76%	93%	n/a	91%[2]	98%	98%	n/a	98%
MCN	50/76%	89%	n/a	92%[2]	96%	93%	n/a	98%
JDA	50/83%	94%[9]	n/a	85%	98%	97%	n/a	
TDA	50%	50%[6]	equ	84%	98%	n/a	98%[4]	
BON-I		85%[7]	equ	92%		98%[8]	98%[4]	
Spillway	50%				98%			
BON-II		60%[5]	70%	90%		98%	98%	

References:

1. All parameters without specific references are the same as the 2010 Proposed Operation.
2. Future turbine survivals were increased 1 to 2%based on improved turbine operations (and design in some cases).
3. LMN spillway survival increase 2.5% due to deflector mods and improved tailrace egress.
4. Sluiceway survival increased 1.5 and 6% for TDA and BON, respectively, due to relocation of outfalls.
5. BON PH2 FGE increased 6% due to completion of the FGE improvement program.
6. TDA FGE is added to simulate increased sluiceway efficiency - turbine entrainment is cut in half (under a 40% spill condition)
7. BON PI FGE based on Bonneville Decision Document.
8. BON PI bypass survival same as BON PII bypass survival (same outfall).
9. JDA FGE based on 1996 FGE studies.

Table D.38 -- 1995 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	0.9	0.1	68%	53%	90%	98%	98%	
LGS	2.1	0.7	68%	53%	90%	98%	98%	
LMN	2.4	0.2	83%	49%	86.5%[4]	98%	98%	
IHR	25.2	25.2	50%	0%	89%[5]	98%	n/a	93%[7]
MCN	7.2	6.5	68%	45%[6]	82%[8]	95%[9]	90%[9]	
JDA	9.7	1.2	80%	32%	72%[10]	98%	92%[11]	
TDA	99.0	99.0	50%	3%	84%[12]	92%[13]	n/a	92.5%[14]
BON-I [15]				9%	90%		82%	82%[16]
Spillway	118.6	74.2	50%			98%		
BON-II				28%	94%		82%[17]	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. FGE prior to ESBS Installation (average over several years of evaluation)
7. IHR sluiceway survival - best professional judgment based on TDA sluiceway survival.
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
11. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
12. Summer PIT results for turbine and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
13. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
15. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Based on coded wire tag studies in late 1980's (Dawley et al. 1996)

Table D.39 -- 1996 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	7.0	2.6	68%	53%	90%	98%	98%	
LGS	8.2	3.5	68%	53%	90%	98%	98%	
LMN	8.2	4.9	83%	49%	86.5%[4]	98%	98%	
IHR	25.4	24.4	50%	54%	89%[5]	98%	100%[6]	
MCN	64.2	67.5	50%	62%	82%[7]	95%[8]	90%[8]	
JDA	66.4	10.6	80%	32%	72%[9]	96%[10]	92%[11]	
TDA	117.1	117.1	50%	3%	84%[12]	92%[13]	n/a	92.5%[14]
BON-I[15]				9%	90%		82%	82%[16]
Spillway	111.3	79.0	50%			98%		
BON-II				28%	94%		82%[17]	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir et. al. N. Am J. of Fish Mgmt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004)
7. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates (Axel, G.A. et al. 2003, 2004)
9. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
10. JDA spill survival is based on 2002 and 2003 RT study results (Counihan et al. 2002, 2003 drafts).
11. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
12. Summer PIT results for turbine and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
13. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
15. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Based on coded wire tag studies in late 1980's (Dawley et al. 1996)

Table D.40 -- 1997 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	5.1	4.1	68%	53%	90%	98%	98%	
LGS	4.7	2.5	68%	53%	90%	98%	98%	
LMN	4.6	3.2	83%	49%	86.5%[4]	98%	98%	
IHR	40.4	40.4	50%	54%	89%[5]	98%	100%[6]	
MCN	70.0	84.5	50%	62%	82%[7]	95%[8]	90%[8]	
JDA	75.4	20.7	50%	32%	72%[9]	96%[10]	92%[11]	
TDA	146.8	146.8	50%	3%	84%[12]	92%[13]	n/a	92.5%[14]
BON-I[15]				9%	90%		82%	82%[16]
Spillway	122.8	91.1	50%			98%		
BON-II				28%	94%		82%[17]	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004)
7. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates (Axel, G.A. et al. 2003, 2004)
9. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
10. JDA spill survival is based on 2002 and 2003 RT study results (Counihan et al. 2002, 2003 drafts).
11. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
12. Summer PIT results for turbine and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
13. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
15. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
16. Best professional judgment - assume no better than PH1 turbine survival.
17. Based on coded wire tag studies in late 1980's (Dawley et al. 1996)

Table D.41 -- 1998 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	1.5	1.4	68%	53%	90%	98%	98%	
LGS	0.0	0.0	68%	53%	90%	98%	98%	
LMN	0.0	0.0	83%	49%	86.5%[4]	98%	98%	
IHR	41.6	41.6	50%	54%	89%[5]	88.5%[7]	100%[6]	
MCN	16.1	21.7	68%	62%	82%[8]	95%[9]	90%[9]	
JDA	94.0	7.9	80%	32%	72%[10]	96%[11]	92%[12]	
TDA	78.3	78.3	50%	3%	84%[13]	92%[14]	n/a	92.5%[15]
BON-I[16]				9%	90%		82%	82%[17]
Spillway	116.8	76.2	50%			98%		
BON-II				28%	94%		82%[18]	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir et. al. N. Am J. of Fish Mgmt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004)
7. IHR spill survival based on Eppard 2000 PIT study.
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
11. JDA spill survival is based on 2002 and 2003 RT study results (Counihan et al. 2002, 2003 drafts).
12. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
13. Summer PIT results for turbine and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
15. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
16. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
17. Best professional judgment - assume no better than PH1 turbine survival.
18. Based on coded wire tag studies in late 1980's (Dawley et al. 1996)

Table D.42 -- 1999 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	4.8	5.2	68%	53%	90%	98%	98%	
LGS	1.3	1.1	68%	53%	90%	98%	98%	
LMN	1.3	1.2	83%	49%	86.5%[4]	98%	98%	
IHR	44.1	44.1	50%	54%	89%[5]	88.5%[7]	100%[6]	
MCN	76.6	80.1	50%	62%	82%[8]	95%[9]	90%[9]	
JDA	116.8	18.4	80%	32%	72%[10]	96%[11]	92%[12]	
TDA	127.0	127.0	50%	3%	84%[13]	92%[14]	n/a	92.5%[15]
BON-I[16]				9%	90%		82%	82%[17]
Spillway	109.3	76.8	50%			98%		
BON-II				28%	94%		98%	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004)
7. IHR spill survival based on Eppard 2000 PIT study.
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
11. JDA spill survival is based on 2002 and 2003 RT study results (Counihan et al. 2002, 2003 drafts).
12. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
13. Summer PIT results for turbine and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
15. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
16. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
17. Best professional judgment - assume no better than PH1 turbine survival.

Table D.43 -- 2000 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	0.0	0.0	68%	53%	90%	98%	98%	
LGS	0.0	0.0	68%	53%	90%	98%	98%	
LMN	0.0	0.0	83%	49%	86.5%[4]	98%	98%	
IHR	30.1	30.1	50%	54%	89%[5]	88.5%[7]	100%[6]	
MCN	4.0	7.5	68%	62%	82%[8]	95%[9]	90%[9]	
JDA	83.9	27.6	80%	32%	72%[10]	96%[11]	92%[12]	
TDA	59.5	59.5	50%	3%	84%[13]	92%[14]	n/a	92.5%[15]
BON-I [16]				9%	90%		82%	82%[17]
Spillway	101.3	87.0	50%			98%		
BON-II				28%	94%		98%	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgmt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004)
7. IHR spill survival based on Eppard 2000 PIT study.
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
11. JDA spill survival is based on 2002 and 2003 RT study results (Counihan et al. 2002, 2003 drafts).
12. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
13. Summer PIT results for turbine and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
15. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
16. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
17. Best professional judgment - assume no better than PH1 turbine survival.

Table D.44 -- 2001 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	0.0	0.0	68%	53%	90%	98%	98%	
LGS	0.0	0.0	68%	53%	90%	98%	98%	
LMN	0.0	0.0	83%	49%	86.5%[4]	98%	98%	
IHR	0.0	0.0	68%	54%	89%[5]	88.5%[7]	100%[6]	
MCN	0.0	0.0	68%	62%	82%[8]	95%[9]	90%[9]	
JDA	0.0	0.0	80%	32%	72%[10]	96%[11]	87%[12]	
TDA	18.6	18.6	50%	3%	84%[13]	92%[14]	n/a	92.5%[15]
BON-I[16]				9%	90%		82%	82%[17]
Spillway	24.9	18.9	50%			98%		
BON-II				28%	94%		98%	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir et. al. N. Am J. of Fish Mgmt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004)
7. IHR spill survival based on Eppard 2000 PIT study.
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
11. JDA spill survival is based on 2002 and 2003 RT study results (Counihan et al. 2002, 2003 drafts).
12. JBS survival for JDA based on 2001 RT summer study results (Counihan, 2001 AFEP Presentation)
13. Summer PIT results for turbine and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
15. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
16. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
17. Best professional judgment - assume no better than PH1 turbine survival.

Table D.45 -- 2003 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	0.0	0.0	68%	53%	90%	93%[19]	98%		98%[18]
LGS	0.0	0.0	68%	53%	90%	98%	98%		
LMN	0.0	0.0	83%	49%	86.5%[4]	96%[20]	98%		
IHR	14.4	14.4	50%	54%	89%[5]	96%[7]	100%[6]		
MCN	0.0	0.0	68%	62%	82%[8]	95%[9]	90%[9]		
JDA	60.0	9.2	80%	32%	72%[10]	96%[11]	92%[12]		
TDA	51.0	51.0	50%	3%	84%[13]	92%[14]	n/a	92.5%[15]	
BON-I[16]				0%	90%		82%	82%[17]	
Spillway	106.0	75.0	50%			98%			
BON-II				28%	94%		98%		

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgmt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004)
7. IHR spill survival based on 2003 summer PIT evaluation (Absolon et al. 2004)
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates (Axel, G.A. et al. 2003, 2004)
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
11. JDA spill survival is based on 2002 and 2003 RT study results (Counihan et al. 2002, 2003 drafts).
12. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
13. Summer PIT results for turbine and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
15. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
16. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
17. Best professional judgment - assume no better than PH1 turbine survival.
18. Spill and RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
19. Spill and RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
20. LMN spill survival based on 2003 RT Studies (Hockersmith et al. 2004).

Table D.46 shows the SR fall chinook individual pool survival estimates for each Lower Snake and Lower Columbia pool and dam reach for 1995 through 2001 and 2003, as estimated using the SIMPAS model. The observed summer flows used for each major reach (LSN and LCO) are listed at the bottom of the table. The reaches start at the head of Lower Granite Pool and end at the tailrace of Bonneville Dam, and each project reach extends from the tailrace of the upstream dam to the tailrace of the downstream dam. Pool survival estimates for LWG, LGS, and LMN are based on empirical reach survival data for each reach. Between 1997 and 2003, IHR and MCN reach survivals were calculated based on the square root of a longer empirical reach that included LMN to MCN. That is, equal survival was assumed through each pool (Sandford and Smith 2002). The 1995 and 1996 IHR and MCN pool survivals were extrapolated from the upstream sampled reaches on a per-mile basis. Because there are six years of empirical estimates for these two reaches, the extrapolated pool survivals based on the per-mile expansions could be compared with empirical survival estimates from these years. The expansion method tended to underestimate pool survival, so correction factors were applied to these extrapolated pool survivals. All years include additional pool survival rates that were extrapolated from the upstream sampled reaches on a per-mile basis (as described in the 2000 Biological Opinion, Appendix D). These included the JDA, TDA, and BON pools. No correction factors were possible for these pools, since there are no corresponding empirical reach survival estimates.

Table D.46 – Per reach pool survivals by year, with **bolded values** based on empirical data:

	1995	1996	1997	1998	1999	2000	2001	2003
LWG	**0.7083**	**0.5040**	**0.3729**	**0.5964**	**0.7451**	**0.5062**	**0.2228**	**0.5497**
LGS	**0.9127**	**0.9378**	**0.5951**	**0.8232**	**0.7449**	**0.8221**	**0.8106**	**0.8818**
LMN	**0.8468**	**0.8388**	**0.6870**	**0.9971**	**0.8978**	**0.8238**	**0.7598**	**0.8889**
IHR	0.9849	0.9933	**0.8891**	**0.9634**	**0.9458**	**0.9780**	**0.7704**	**0.8919**
MCN	1.0562	1.0681	**0.9540**	**0.9708**	**0.9223**	**0.9961**	**0.8411**	**0.9825**
JDA	0.7418	0.7571	0.5606	0.8655	0.7449	0.7967	0.6053	0.8144
TDA	0.9101	0.9160	0.8331	0.9554	0.9113	0.9308	0.8536	0.9373
BON	0.8383	0.8485	0.7106	0.9183	0.8404	0.8744	0.7435	0.8859
Observed seasonal average flows for each reach:								
LSN	97	138	158	112	116	84	43	89
LCO	249	360	441	285	303	254	120	242

The second step in the analytical process for SR fall chinook was to determine if a relationship between flow and survival for each pool or for an entire reach existed and, if so, to describe it in the form of a functional relationship. Hydro staff regressed the lower Snake River and the lower Columbia reach survivals (single-pool survivals multiplied together to produce two 4-pool-reach survivals) from Table D.46 on seasonal average flows, and a flow-survival relationship was developed (Attachment 3).

The final step in the process was to apply the reach survival relationship to the seasonal average flows obtained from BPA's hydro-system modeling for both the proposed hydro operation and the reference operation. Using the developed flow-survival relationships, juvenile reach survivals were calculated for both the reference operation flows and the proposed hydro operation flows for the lower Snake and lower Columbia reaches. The 4^{th} root of the reach survivals was then calculated to obtain average single-pool survivals for each reach. Finally, the single-pool survivals for the reference operation were divided by the single-pool survivals of the proposed action operation to obtain a pool adjustment factor for use in estimating the reference operation pool survivals in the SIMPAS model for the gap analysis.

In addition to changes in flows and spills between the reference and proposed hydro operations, certain dam passage parameters also changed between the two operations. For example, spill efficiency and diel passage parameters changed under different spill conditions, particularly when changing from 12-hour spill at a project in the proposed hydro operation to 24-hour spill in the reference operation. The various dam passage parameters used in the survival gap analyses related to fall chinook salmon for the reference operation and the 2004, 2010 and 2014 proposed hydro operations are shown on Tables D.47 through D.50.

For the gap analysis for LCR fall chinook, Hydro staff assumed the juvenile survival rates for that species would be equivalent to the respective McNary to Bonneville dam survival rates of SR fall chinook, including the flow-survival relationship.

Table D.47 -- Proposed 2004 Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	53%	n/a	90%	93%[3]	98%	n/a	98%[3]
LGS	50/68%	53%	n/a	90%	98%	98%	n/a	
LMN	50/83%	49%	n/a	86.5%[4]	95.6%[7]	98%	n/a	
IHR	50/68%	54%	n/a	89%[5]	96%[5]	98%	n/a	98%[3]
MCN	50/68%	62%	n/a	82%[6]	95%[8]	90%[8]	n/a	
JDA	50/80%	32%	n/a	72%[9]	98%[10]	92%[9]	n/a	
TDA	50%	n/a	equ[17]	84%[11]	97%[12]	n/a	96%[11]	
BON-I		n/a	equ[17]	92%[14]		n/a	92%[15]	
Spillway	50%				98%			
BON-II[13]		28%	47%[16]	94%		98%	98%[18]	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
3. Spill and RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. Muir et. al. N. Am J. of Fish Mgmt. 2001. Spring Chinook - best available data.
5. Absolon et al, 2003, PIT subyearling chinook turbine and spill survival at IHR.
6. Peery et al 2003, draft report, RT subyearling chinook turbine survival at MCN.
7. LMN spill survival - average of '94 survival estimates (.927, .984). Muir et al. 1995
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
9. Route specific 30/30 route specific JBS and turbine survival from summer RT studies at JDA in 2003.
10. Average 30/30 route specific spill survival from summer RT studies at JDA in 2002 and 2003.
11. Summer PIT results for turbine and sluiceway passage at TDA in 2000 - Absolon et al. 2002.
12. Best professional judgment given installation of spillway divider wall in 2003.
13. Bonneville Powerhouse priority is PH2.
14. Best professional judgment - improved PH1 turbine survival due to install of MGR units.
15. Best professional judgment - assume no better than PH1 turbine survival.
16. Best professional judgment based on limited 1999 sluiceway studies.
17. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
18. BON sluiceway survival based on best professional judgment.

Table D.48 -- Reference Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	53%	n/a	90%	93%[3]	98%	n/a	98%[3]
LGS	50/68%	53%	n/a	90%	98%	98%	n/a	
LMN	50/83%	49%	n/a	86.5%[4]	95.6%[7]	98%	n/a	
IHR	50/68%	54%	n/a	89%[5]	96%[5]	98%	n/a	98%[3]
MCN	50/68%	62%	n/a	82%[6]	95%[8]	90%[8]	n/a	
JDA	50/80%	32%	n/a	72%[9]	98%[10]	92%[9]	n/a	
TDA	50%	n/a	equ[17]	84%[11]	97%[12]	n/a	96%[11]	
BON-I		n/a	equ[17]	92%[14]		n/a	92%[15]	
Spillway	50%				98%			
BON-II[13]		28%	47%[16]	94%		98%	98%[18]	

References:

1. All parameters without specific references were taken from the 2000 Biological Opinion, Appendix page D-13.
2. Diels for very low or night only spills are based on 2000 Biological Opinion, Appendix page D-13. Diel was 50% for significant 24 hour spills.
3. Spill and RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. Muir et. al. N. Am J. of Fish Mgmt. 2001. Spring Chinook - best available data.
5. Absolon et al, 2003, PIT subyearling chinook turbine and spill survival at IHR.
6. Peery et al 2003, draft report, RT subyearling chinook turbine survival at MCN.
7. LMN spill survival - average of '94 survival estimates (.927, .984). Muir et al. 1995
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2003, 2004)
9. Route specific 30/30 route specific JBS and turbine survival from summer RT studies at JDA in 2003.
10. Average 30/30 route specific spill survival from summer RT studies at JDA in 2002 and 2003.
11. Summer PIT results for turbine and sluiceway passage at TDA in 2000 - Absolon et al. 2002.
12. Best professional judgment given installation of spillway divider wall in 2003.
13. Bonneville Powerhouse priority is PH2.
14. Best professional judgment - improved ph1 turbine survival due to install of MGR units.
15. Best professional judgment - assume no better than PH1 turbine survival.
16. Best professional judgment based on limited 1999 sluiceway studies.
17. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
18. BON sluiceway survival based on best professional judgment.

Table D.49 -- Proposed 2010 Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Diel Passage	FGE	SLPE	Turbine Survival[2]	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	53%	n/a	91%	93%	98%	n/a	98%
LGS	50/68%	53%	n/a	90%	98%	98%	n/a	
LMN	50/83%	49%	n/a	86.5%	95.6%	98%	n/a	98%
IHR	50/68%	54%	n/a	89%	98%[3]	98%	n/a	98%
MCN	50/68%	62%	n/a	83%	96%[4]	94%[5]	n/a	98%
JDA	50/80%	32%	n/a	81%[6]	98%	96%[7]	n/a	
TDA	50%	n/a	equ	84%	98%[8]	n/a	96%	
BON-I		n/a	equ	92%		n/a	92%	
Spillway	50%				98%			
BON-II		38%[9]	47%	94%		98%	98%	

References:

1. All parameters without specific references are the same as the 2004 Proposed Operation.
2. Turbine survivals increased 1 to 2% at LGR through MCN due to improved turbine operations (and design in some cases).
3. Spillway survival increase of 2% due to combination of RSW, bulk spill, divider wall and deflector mods.
4. MCN spillway survival increased 1% due to improved egress conditions.
5. MCN bypass survival increased 4% due to outfall relocation and improved egress.
6. JDA turbine survival increased 9% due to combination of improved operation and guidewall (8% for egress and 1% for turbine).
7. JDA bypass survival increased 4% due to improved egress.
8. TDA spill survival, 1% increase due to spill basin improvements and 1% due to egress improvements.
9. BON PH2 FGE increased 10% due to FGE improvement program.

Table D.50 -- Proposed 2014 Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Diel Passage	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	53%	n/a	91%	93%	98%	n/a	98%
LGS	50/68%	53%	n/a	91%[2]	98%	98%	n/a	
LMN	50/83%	49%	n/a	87.5%[2]	95.6%	98%	n/a	98%
IHR	50/68%	54%	n/a	91%[2]	98%	98%	n/a	98%
MCN	50/68%	62%	n/a	84%[2]	96%	94%	n/a	98%
JDA	50/80%	64%[3]	n/a	81%	98%	96%	n/a	
TDA	50%	34%[6]	equ	84%	98%	n/a	98%[7]	
BON-I		35%[4]	equ	92%		98%[8]	96%[7]	
Spillway	50%				98%			
BON-II		40%[5]	47%	94%		98%	98%	

References:

1. All parameters without specific references are the same as the 2010 Proposed Operation.
2. Turbine survivals increased 1 to 2% at LGR through MCN due to improved turbine operations (and design in some cases).
3. JDA FGE based on 2002 FGE studies.
4. BON PI FGE based on Bonneville Decision Document.
5. BON PH2 FGE increased 12% due to FGE improvement program.
6. TDA FGE is added to simulate increased sluiceway efficiency - turbine entrainment is cut in third (under a 40% spill condition)
7. Sluiceway survival increased 2 and 4% for TDA and BON, respectively, due to relocation of outfalls.
8. BON PI bypass survival same as BON PII bypass survival (same outfall).

3.4 RESULTS OF THE GAP ANALYSES

For the following gap analyses, NOAA Fisheries used the estimated SIMPAS survival rates for the various listed stocks of spring/summer chinook salmon, steelhead, and fall chinook salmon resulting from the respective reference operations and compared them to the survivals associated with the Action Agencies' proposed hydro operations. The difference in survival identified by this analysis is expected to represent the effects to the listed species that may be attributable to the existence of the projects (dams and reservoirs) compared to the proposed operation of the projects. Three different gap analyses were conducted, one to measure the near-term (2004) survival gap, a second to measure the intermediate-term (2010) survival gap and a third to measure the long-term (2014) survival gap.

3.4.1 SR Spring/Summer Chinook

The previous discussion was provided to explain and illustrate the analytical approach that was used to define the gap in survival through the FCRPS between a reference operation and the proposed hydro operation. The SIMPAS modeling results shown below in Tables D.51 through D.53 for SR spring/summer chinook provide an indication of the relative difference, or "gap," in hydro survival between the two operations. This relative difference in survival is calculated for each year in the 10-year study period by subtracting the reference operation system survival from the proposed action system survival and dividing the difference by the reference operation system survival. This was done for each of the three proposed operations (2004, 2010 and 2014).

Under the reference operation for SR spring/summer chinook, estimated juvenile system survivals with D ranged from over 51% to nearly 54% during the 1994-2003 study period, with a mean survival rate of over 52.5% (Table D.51). In-river survivals ranged from about 42% to over 59%, with a mean value of about 54% during the same 10-year period.

For the near-term (2004) proposed hydro operation, estimated juvenile system survivals with D for this listed stock ranged from just under 49% to over 53% during the 1994-2003 study period, with a mean value of over 51.5%, and in-river survivals ranged from 38% to almost 58%, with a mean of over 50% during the 10-year period (Table D.51). For the intermediate-term 2010 proposed hydro operation, estimated juvenile system survivals for this listed stock ranged from 50% to over 54% during the 1994-2003 study period, with a mean value of over 52%, and in-river survivals ranged from over 41% to over 62%, with a mean of just over 54% during the 10-year period (Table D.52). For the long-term 2014 proposed hydro operation, estimated juvenile system survivals for this listed stock ranged from 51% to over 55% during the 1994-2003 study period, with a mean value of 53%, and in-river survivals ranged from nearly 43% to over 65%, with a mean of over 56% during the 10-year period (Table D.53).

For SR spring/summer chinook, the estimated relative gap in the near-term (2004) over the 10-year study period for total system survival (including differential delayed mortality associated with transportation) between the proposed action and the reference operation is -1.9%[22] and

[22] The estimated relative gap for total system survival between the proposed hydro operation and the reference operation was calculated using a relative difference of the mean survival rates (proposed minus reference/reference) over the 10-year study period (1994-2003).

ranges from -0.2% to -4.7% (Figure D.1). Table D.51 shows the estimated relative gap for in-river survival through the FCRPS between the proposed hydro operation and the reference operation is -7.3% and ranges from -2.6% to -11.0%. The estimated survival multiplier, or relative difference in survival between the reference operation and the proposed hydro operation for system survival with D, is 1.02[23] and ranges from 1.00 to 1.05. The estimated survival multiplier for in-river survival is 1.08, with a range from 1.03 up to 1.12.

The estimated relative gap for SR spring chinook in the intermediate-term (2010) over the 10-year study period for total system survival (including differential delayed survival associated with transportation) between the proposed action and the reference operation is -0.4% and ranges from -2.0% to +1.4% (Figure D.2). There is no relative difference in in-river survival through the FCRPS between the proposed hydro operation and the reference operation, with survival ranging from -4.9% to +5.5% (Table D.52). The estimated survival multiplier, or relative difference in survival between the reference operation and the proposed hydro operation for system survival with D, indicates that little or no survival improvement is needed, with a range of improvement needed up to 1.02. The estimated survival multiplier for in-river survival also indicates that no survival improvement is needed with a range up to 1.05.

The estimated relative gap for SR spring chinook in the long-term (2014) over the 10-year study period for total system survival (including differential delayed survival associated with transportation) between the proposed action and the reference operation is +1.1% and ranges from -0.3% to +3.2% (Figure D.3). The estimated relative gap for in-river survival through the FCRPS between the proposed hydro operation and the reference operation is +4.0% and ranges from no gap to +10.3% (Table D.53). The estimated survival multiplier, or relative difference in survival between the reference operation and the proposed hydro operation for system survival with D, indicates that no survival improvement is needed, on average, with a range of improvement of 1.00 or less. The estimated survival multiplier for in-river survival also indicates that no survival improvement is needed with a similar range of 1.00 or less.

3.4.2 UCR Spring Chinook

Under the reference operation for UCR spring chinook, estimated juvenile in-river survival rates through the lower Columbia River ranged from about 60% up to nearly 77% during the 1994-2003 study period, with a mean value of over 71% (Table D.51). For the near-term (2004) proposed hydro operation, the estimated juvenile in-river survivals for UCR spring chinook ranged from 55% up to nearly 75% during the 1994-2003 study period, with a mean value of about 67% (Table D.51). For the intermediate-term (2010) proposed hydro operation, Table D.52 shows the estimated juvenile in-river survivals for UCR spring chinook range from over 59% up to almost 80% during the 1994-2003 study period, with a mean value of nearly 72%. For the long-term (2014) proposed hydro operation, Table D.53 shows the estimated juvenile in-river survivals for UCR spring chinook range from over 60% up to nearly 83% during the 1994-2003 study period, with a mean value of over 73%.

[23] The estimated survival multiplier is a measure of the amount of survival improvement needed in another life stage for this listed species to make up the system survival gap. A geometric mean was used to calculate the relative difference (reference/proposed) in survival between the reference and proposed hydro operations, which dampens out the effects of both extreme high and low survival differences.

The estimated relative gap between the proposed hydro operation and the reference operation in the near-term (2004) for UCR spring chinook in-river survival through four Columbia River FCRPS dams and reservoirs over the 10-year study period is -5.8%, and ranges from -2.6% up to -8.5% (Figure D.10). The estimated survival multiplier for UCR spring chinook, or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River projects, is 1.06, ranging from 1.03 up to 1.09 (Table D.51).

For UCR spring chinook, the estimated relative gap between the proposed hydro operation and the reference operation in the intermediate-term (2010) for in-river survival through four Columbia River FCRPS dams and reservoirs is +0.7% and ranges from -1.1% to +3.7% (Figure D.11). The estimated long-term survival multiplier for UCR spring chinook, or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River projects is less than 1.0, indicating that no survival improvement is needed although the range does slightly exceed the mean at 1.01 (Table D.52).

The long-term (2014) estimated relative gap between the proposed hydro operation and the reference operation for UCR spring chinook in-river survival through four Columbia River FCRPS dams and reservoirs is +2.9% and ranges from +0.5% to +7.5% (Figure D.12). The estimated long-term survival multiplier for UCR spring chinook, or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River projects, is less than 1.0, indicating that no survival improvement is needed (Table D.53).

3.4.3 LCR Spring Chinook

For LCR spring chinook in the reference operation, the estimated juvenile in-river survival rates through Bonneville pool and dam on the lower Columbia River ranged from over 87% up to 94% during the 1994-2003 study period, with a mean value of over 91% (Table D.51). For the near-term (2004) proposed hydro operation, Table D.51 shows the estimated juvenile in-river survivals for LCR spring chinook ranged from under 86% up to over 93% during the 1994-2003 study period, with a mean value of 90%. For the intermediate-term (2010) proposed hydro operation, estimated juvenile in-river survivals for LCR spring chinook ranged from under 86% up to over 93% during the 1994-2003 study period, with a mean value of slightly over 90% (Table D.52). For the long-term (2014) proposed hydro operation, estimated juvenile in-river survivals for LCR spring chinook ranged from about 86% up to just below 95% during the 1994-2003 study period, with a mean value of over 90% (Table D.53).

For LCR spring chinook, the estimated relative gap between the proposed hydro operation and the reference operation in the near term (2004) for in-river survival over the 10-year study period through Bonneville Dam is -1.6%, and ranges from -1.9% to -0.6%. The estimated survival multiplier in the near term for LCR spring chinook, or the relative difference in survival between the reference operation and the proposed hydro operation for in-river survival through Bonneville Dam on the lower Columbia River, is 1.02, ranging from a little less than 1.01 up to 1.02 (Table D.51).

The estimated relative gap in the intermediate-term (2010) for in-river survival over the 10-year study period through Bonneville Dam between the proposed hydro operation and the reference operation is -1.4% and ranges from -1.9% to -0.5%. Table D.52 shows the estimated survival multiplier for LCR spring chinook, or the relative difference in survival between the reference operation and the proposed hydro operation for in-river survival through Bonneville Dam on the lower Columbia River, is about 1.02, ranging from less than 1.01to 1.02.

The estimated relative gap in the long-term (2014) for in-river survival over the 10-year study period through Bonneville Dam between the proposed hydro operation and the reference operation is -0.8% and ranges from -1.8% up to +1.0%. Table D.53 shows the estimated survival multiplier for LCR spring chinook, or the relative difference in survival between the reference operation and the proposed hydro operation for in-river survival through Bonneville Dam on the lower Columbia River, is 1.01, ranging from no survival improvement needed to 1.02.

Table D.51 – Summary of Estimated Survival Rates for Yearling Chinook Salmon from 2004 Hydro Gap Analysis

Gap Analysis - Yearling Chinook Summary Page	**Study Years**										
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2004 Proposed Hydro Operation											
SR Sp Chinook System Survival with Wild D	52.4%	48.8%	52.5%	53.4%	50.4%	50.4%	50.7%	52.9%	51.4%	52.5%	51.5%
SR Sp Chin In-river Survival (without Transport)	50.3%	50.1%	54.5%	57.7%	50.4%	53.0%	46.6%	38.3%	53.7%	47.3%	50.2%
Total % Transported	95.1%	61.4%	73.4%	72.1%	67.7%	68.6%	92.1%	96.4%	60.7%	95.3%	78.3%
UCR Sp Chinook In-river Survival (4 projects)	70.4%	66.5%	73.2%	74.9%	65.9%	69.5%	65.3%	55.1%	67.9%	64.3%	67.3%
LCR Sp Chinook In-river Survival (1 project)	91.6%	89.1%	92.4%	93.5%	89.5%	92.1%	86.7%	85.5%	91.1%	87.9%	90.0%
Reference Operation											**Mean**
SR Sp Chinook System Survival with Wild D	52.5%	50.7%	53.6%	53.9%	51.7%	51.7%	51.2%	53.0%	53.9%	52.9%	52.5%
SR Sp Chin In-river Survival (without Transport)	54.2%	54.0%	57.7%	59.3%	54.3%	56.0%	52.4%	42.2%	58.2%	52.9%	54.1%
Total % Transported	95.1%	55.9%	70.6%	70.0%	62.7%	64.1%	89.2%	96.5%	53.1%	92.1%	74.9%
UCR Sp Chinook In-river Survival (4 projects)	75.2%	71.0%	76.9%	76.9%	70.4%	72.9%	69.9%	60.2%	72.7%	68.3%	71.4%
LCR Sp Chinook In-river Survival (1 project)	93.4%	90.6%	93.8%	94.0%	91.1%	93.5%	88.3%	87.1%	92.8%	89.2%	91.4%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Sp Chinook System Survival with Wild D	0.1%	1.9%	1.1%	0.5%	1.4%	1.3%	0.4%	0.1%	2.5%	0.5%	1.0%
SR Sp Chin In-river Survival (without Transport)	3.9%	3.9%	3.2%	1.6%	4.0%	3.0%	5.8%	3.9%	4.4%	5.6%	3.9%
Total % Transported	0.0%	-5.5%	-2.8%	-2.1%	-5.1%	-4.5%	-2.9%	0.1%	-7.6%	-3.1%	-3.3%
UCR Sp Chinook In-river Survival (4 projects)	4.7%	4.5%	3.7%	2.0%	4.6%	3.3%	4.6%	5.1%	4.8%	4.0%	4.1%
LCR Sp Chinook In-river Survival (1 project)	1.8%	1.5%	1.3%	0.6%	1.6%	1.4%	1.6%	1.5%	1.6%	1.3%	1.4%
Relative Difference (Reference/Proposed)											**Geomean**
SR Sp Chinook System Survival with Wild D	100.2%	104.0%	102.1%	100.9%	102.7%	102.6%	100.8%	100.3%	104.9%	100.9%	101.9%
SR Sp Chin In-river Survival (without Transport)	107.8%	107.8%	105.9%	102.7%	107.9%	105.7%	112.4%	110.3%	108.2%	111.8%	108.0%
UCR Sp Chinook In-river Survival (4 projects)	106.7%	106.8%	105.1%	102.6%	106.9%	104.8%	107.1%	109.3%	107.1%	106.2%	106.2%
LCR Sp Chinook In-river Survival (1 project)	102.0%	101.7%	101.4%	100.6%	101.8%	101.5%	101.8%	101.8%	101.8%	101.5%	101.6%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Sp Chinook System Survival with Wild D	-0.2%	-3.8%	-2.1%	-0.9%	-2.6%	-2.5%	-0.8%	-0.3%	-4.7%	-0.9%	-1.9%
SR Sp Chin In-river Survival (without Transport)	-7.2%	-7.3%	-5.6%	-2.6%	-7.3%	-5.4%	-11.0%	-9.3%	-7.6%	-10.6%	-7.3%
UCR Sp Chinook In-river Survival (4 projects)	-6.3%	-6.4%	-4.9%	-2.6%	-6.5%	-4.5%	-6.6%	-8.5%	-6.6%	-5.8%	-5.8%
LCR Sp Chinook In-river Survival (1 project)	-1.9%	-1.7%	-1.4%	-0.6%	-1.8%	-1.5%	-1.8%	-1.7%	-1.8%	-1.5%	-1.6%

Table D.52 – Summary of Estimated Survival Rates for Yearling Chinook Salmon from 2010 Hydro Gap Analysis

Gap Analysis - Yearling Chinook Summary Page					**Study Years**						
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2010 Proposed Hydro Operation											
SR Sp Chinook System Survival with Wild D	52.5%	50.0%	53.5%	54.6%	51.4%	51.5%	50.9%	53.0%	52.9%	52.6%	52.3%
SR Sp Chin In-river Survival (without Transport)	53.8%	54.0%	59.4%	62.6%	54.3%	57.2%	49.9%	41.5%	58.1%	50.7%	54.1%
Total % Transported	95.2%	62.4%	74.1%	72.4%	68.6%	69.4%	92.3%	96.5%	61.7%	95.4%	78.8%
UCR Sp Chinook In-river Survival (4 projects)	75.1%	70.8%	79.1%	79.8%	70.2%	74.3%	69.6%	59.5%	72.4%	68.6%	71.9%
LCR Sp Chinook In-river Survival (1 project)	91.6%	89.1%	93.3%	93.5%	89.5%	92.2%	86.8%	85.6%	91.2%	88.0%	90.1%
Reference Operation											**Mean**
SR Sp Chinook System Survival with Wild D	52.5%	50.7%	53.6%	53.9%	51.7%	51.7%	51.2%	53.0%	53.9%	52.9%	52.5%
SR Sp Chin In-river Survival (without Transport)	54.2%	54.0%	57.7%	59.3%	54.3%	56.0%	52.4%	42.2%	58.2%	52.9%	54.1%
Total % Transported	95.1%	55.9%	70.6%	70.0%	62.7%	64.1%	89.2%	96.5%	53.1%	92.1%	74.9%
UCR Sp Chinook In-river Survival (4 projects)	75.2%	71.0%	76.9%	76.9%	70.4%	72.9%	69.9%	60.2%	72.7%	68.3%	71.4%
LCR Sp Chinook In-river Survival (1 project)	93.4%	90.6%	93.8%	94.0%	91.1%	93.5%	88.3%	87.1%	92.8%	89.2%	91.4%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Sp Chinook System Survival with Wild D	-0.1%	0.8%	0.1%	-0.7%	0.3%	0.3%	0.3%	0.0%	1.1%	0.3%	0.2%
SR Sp Chin In-river Survival (without Transport)	0.4%	0.0%	-1.7%	-3.3%	0.1%	-1.2%	2.5%	0.7%	0.1%	2.2%	0.0%
Total % Transported	-0.1%	-6.4%	-3.5%	-2.4%	-5.9%	-5.3%	-3.0%	0.0%	-8.6%	-3.3%	-3.9%
UCR Sp Chinook In-river Survival (4 projects)	0.1%	0.2%	-2.2%	-2.9%	0.3%	-1.4%	0.3%	0.6%	0.3%	-0.4%	-0.5%
LCR Sp Chinook In-river Survival (1 project)	1.8%	1.5%	0.4%	0.5%	1.6%	1.3%	1.5%	1.5%	1.6%	1.3%	1.3%
Relative Difference (Reference/Proposed)											**Geomean**
SR Sp Chinook System Survival with Wild D	99.9%	101.5%	100.2%	98.6%	100.7%	100.5%	100.5%	100.0%	102.0%	100.6%	100.4%
SR Sp Chin In-river Survival (without Transport)	100.8%	100.0%	97.1%	94.8%	100.2%	97.9%	105.1%	101.6%	100.2%	104.4%	100.2%
UCR Sp Chinook In-river Survival (4 projects)	100.1%	100.3%	97.3%	96.4%	100.4%	98.1%	100.4%	101.1%	100.4%	99.4%	99.4%
LCR Sp Chinook In-river Survival (1 project)	102.0%	101.7%	100.5%	100.6%	101.8%	101.5%	101.8%	101.8%	101.8%	101.5%	101.5%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Sp Chinook System Survival with Wild D	0.1%	-1.5%	-0.2%	1.4%	-0.6%	-0.5%	-0.5%	0.0%	-2.0%	-0.6%	-0.4%
SR Sp Chin In-river Survival (without Transport)	-0.8%	0.0%	2.9%	5.5%	-0.2%	2.2%	-4.9%	-1.6%	-0.2%	-4.2%	0.0%
UCR Sp Chinook In-river Survival (4 projects)	-0.1%	-0.3%	2.8%	3.7%	-0.4%	2.0%	-0.4%	-1.1%	-0.4%	0.6%	0.7%
LCR Sp Chinook In-river Survival (1 project)	-1.9%	-1.7%	-0.5%	-0.6%	-1.8%	-1.4%	-1.7%	-1.7%	-1.7%	-1.4%	-1.4%

Table D.53 – Summary of Estimated Survival Rates for Yearling Chinook Salmon from 2014 Hydro Gap Analysis

Gap Analysis - Yearling Chinook Summary Page					**Study Years**						
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2014 Proposed Hydro Operation											
SR Sp Chinook System Survival with Wild D	52.6%	51.5%	54.7%	55.6%	52.4%	52.9%	51.0%	53.1%	54.7%	52.7%	53.1%
SR Sp Chin In-river Survival (without Transport)	55.1%	56.0%	61.7%	65.4%	56.3%	59.9%	52.4%	42.6%	60.3%	53.0%	56.3%
Total % Transported	95.2%	56.7%	71.4%	71.1%	63.3%	65.0%	92.4%	96.5%	54.8%	95.6%	76.2%
UCR Sp Chinook In-river Survival (4 projects)	76.3%	72.2%	80.6%	82.7%	71.7%	76.4%	71.0%	60.5%	74.0%	69.8%	73.5%
LCR Sp Chinook In-river Survival (1 project)	91.7%	89.6%	93.8%	94.9%	90.1%	93.4%	87.2%	85.7%	91.7%	88.1%	90.6%
Reference Operation											**Mean**
SR Sp Chinook System Survival with Wild D	52.5%	50.7%	53.6%	53.9%	51.7%	51.7%	51.2%	53.0%	53.9%	52.9%	52.5%
SR Sp Chin In-river Survival (without Transport)	54.2%	54.0%	57.7%	59.3%	54.3%	56.0%	52.4%	42.2%	58.2%	52.9%	54.1%
Total % Transported	95.1%	55.9%	70.6%	70.0%	62.7%	64.1%	89.2%	96.5%	53.1%	92.1%	74.9%
UCR Sp Chinook In-river Survival (4 projects)	75.2%	71.0%	76.9%	76.9%	70.4%	72.9%	69.9%	60.2%	72.7%	68.3%	71.4%
LCR Sp Chinook In-river Survival (1 project)	93.4%	90.6%	93.8%	94.0%	91.1%	93.5%	88.3%	87.1%	92.8%	89.2%	91.4%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Sp Chinook System Survival with Wild D	-0.1%	-0.7%	-1.1%	-1.7%	-0.7%	-1.1%	0.1%	-0.1%	-0.8%	0.2%	-0.6%
SR Sp Chin In-river Survival (without Transport)	-1.0%	-2.0%	-4.1%	-6.1%	-2.0%	-3.8%	0.0%	-0.4%	-2.1%	-0.2%	-2.2%
Total % Transported	-0.1%	-0.8%	-0.8%	-1.1%	-0.6%	-0.9%	-3.2%	-0.1%	-1.7%	-3.5%	-1.3%
UCR Sp Chinook In-river Survival (4 projects)	-1.2%	-1.2%	-3.7%	-5.8%	-1.2%	-3.6%	-1.1%	-0.3%	-1.3%	-1.5%	-2.1%
LCR Sp Chinook In-river Survival (1 project)	1.7%	1.1%	0.0%	-0.9%	1.1%	0.1%	1.1%	1.4%	1.1%	1.1%	0.8%
Relative Difference (Reference/Proposed)											**Geomean**
SR Sp Chinook System Survival with Wild D	99.8%	98.6%	98.0%	96.9%	98.7%	97.9%	100.2%	99.9%	98.6%	100.3%	98.9%
SR Sp Chin In-river Survival (without Transport)	98.3%	96.5%	93.4%	90.7%	96.5%	93.6%	100.0%	99.1%	96.5%	99.7%	96.4%
UCR Sp Chinook In-river Survival (4 projects)	98.5%	98.3%	95.4%	93.0%	98.3%	95.3%	98.4%	99.5%	98.3%	97.8%	97.3%
LCR Sp Chinook In-river Survival (1 project)	101.8%	101.2%	100.0%	99.0%	101.2%	100.1%	101.3%	101.6%	101.2%	101.3%	100.9%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Sp Chinook System Survival with Wild D	0.2%	1.4%	2.0%	3.2%	1.3%	2.2%	-0.2%	0.1%	1.5%	-0.3%	1.1%
SR Sp Chin In-river Survival (without Transport)	1.8%	3.6%	7.0%	10.3%	3.6%	6.8%	0.0%	0.9%	3.6%	0.3%	4.0%
UCR Sp Chinook In-river Survival (4 projects)	1.5%	1.7%	4.9%	7.5%	1.8%	4.9%	1.6%	0.5%	1.7%	2.3%	2.9%
LCR Sp Chinook In-river Survival (1 project)	-1.8%	-1.2%	0.0%	1.0%	-1.2%	-0.1%	-1.3%	-1.6%	-1.1%	-1.3%	-0.8%

3.4.4 SR Steelhead

Similar to the SR spring chinook survival gap analysis, the estimated SIMPAS survival rates for SR steelhead resulting from the reference operation were compared to the survivals associated with the Action Agencies' proposed hydro operations for 2004, 2010 and 2014. The difference in survival identified by this gap analysis is expected to represent the effects to the listed species that may be attributable to the existence of the projects (dams and reservoirs) compared to the proposed operation and system configuration of the projects.

The SIMPAS modeling results shown below in Tables D.54, D.55, and D.56 provide an indication of the relative difference in hydro survival between the three proposed operations and the reference operation. This relative difference in survival is calculated for each year in the 10-year study period by subtracting the reference operation system survival from the respective proposed action system survival and dividing the difference by the reference operation system survival.

Under the reference operation for SR steelhead, Table D.54 shows the estimated juvenile system survivals with D ranged from 43% to nearly 54% during the 1994-2003 study period, with a mean value of under 50%. In-river survivals ranged from 6% to 47%, with a mean of about 34% over the study period.

For the near-term (2004) proposed hydro operation, estimated juvenile system survivals with D for this listed stock ranged from over 41% up to over 53% during the 1994-2003 study period, with a mean value of about 49%, and in-river survivals ranged from 5% to about 43% with a mean of over 30% over the study period (Table D.54).

Thus, for SR steelhead, the estimated relative gap between the 2004 proposed hydro operation and the reference operation over the 10-year study period for system survival in the near term (including differential delayed mortality associated with transportation) is -1.3% and ranges from -3.3% to +0.4% (Figure D.4). The estimated relative gap for in-river survival through the FCRPS between the 2004 proposed hydro operation and the reference operation is -10.5% and ranges from -30.6% to -1.6%. The estimated survival multiplier, or relative difference in survival between the reference operation and the 2004 proposed hydro operation for system survival with D, is 1.01 and ranges from no survival improvement needed to 1.03. The estimated survival multiplier for in-river survival is over 1.16, with a range from 1.02 up to 1.44 (Table D.54).

For the intermediate-term (2010) proposed hydro operation, estimated juvenile system survivals with D for this listed stock ranged from over 41% up to over 53% during the 1994-2003 study period, with a mean value of about 50%, and in-river survivals ranged from 5% to 46%, with a mean of nearly 33% over the study period (Table D.55).

Thus, the estimated mid-term relative gap between the 2010 proposed hydro operation and the reference operation in system survival with D over the 10-year study period is a -0.1% and ranges between -3.1% and +1.8% (Figure D.5). The estimated long-term relative gap for in-river survival through the FCRPS between the 2010 proposed hydro operation and the reference operation is -3.4% and ranges from -26% to +7%. The estimated survival multiplier, or relative difference in survival between the reference operation and the 2010 proposed hydro operation for system survival with D, indicates that little or no survival improvement is needed on average with a range of improvement up to 1.03. The estimated survival multiplier for in-river survival is 1.08, ranging from no survival improvement needed up to 1.35% (Table D.55).

For the long-term (2014) proposed hydro operation, estimated juvenile system survivals with D for this listed stock ranged from over 41% up to 54% during the 1994-2003 study period, with a mean value of less than 50%, and in-river survivals ranged from 5% to 47% with a mean of over 33% over the study period (Table D.56).

Thus, the estimated long-term relative gap between the 2014 proposed hydro operation and the reference operation in system survival with D over the 10-year study period is a -0.1% and ranges between -3.1% and +2.2% (Figure D.6). The estimated long-term relative gap for in-river survival through the FCRPS between the 2014 proposed hydro operation and the reference operation is -1.3% and ranges from -25% to +10%. The estimated survival multiplier, or relative difference in survival between the reference operation and the 2014 proposed hydro operation for system survival with D, indicates that no survival improvement is needed with a range of improvement up to 1.03. The estimated survival multiplier for in-river survival is 1.06, ranging from no survival improvement needed up to 1.33% (Table D.56).

3.4.5 UCR Steelhead

Under the reference operation for UCR steelhead (and for MCR steelhead that migrate through all four lower Columbia River dams), the estimated juvenile in-river survivals through the lower Columbia River ranged from about 21% to over 67% during the 1994-2003 study period, with a mean value of about 51% (Table D.54). For the near-term (2004) proposed hydro operation, the estimated juvenile system survivals for this listed stock ranged from nearly 16% up to about 62% during the study period, with a mean value of nearly 47% (Table D.54).

For UCR steelhead (and for MCR steelhead that migrate through all four lower Columbia River dams), the estimated relative survival gap between the proposed action and the reference operation in the near-term (2004) over the study period through all four Columbia River FCRPS dams and reservoirs is -9.1%, and ranges from -22% to -1.5% (Figure D.13). The estimated survival multiplier for UCR steelhead, or the relative difference in survival between the reference operation and the 2004 proposed hydro operation for in-river survival through the lower Columbia River projects, is 1.12, ranging from 1.02 up to 1.29 (Table D.54).

For the mid-term (2010) proposed hydro operation, Table D.55 shows the estimated juvenile system survivals for this listed stock range from under 18% up to nearly 66% during the study period, with a mean value of about 50%.

Thus, for UCR steelhead (and for MCR steelhead that migrate through all four lower Columbia River dams), the estimated relative gap between the proposed hydro operation and the reference operation in the mid-term (2010) for in-river survival through four Columbia River FCRPS dams and reservoirs closes to -2.9%, and ranges from -17.2% to +5.1% (Figure D.14). The estimated long-term survival multiplier for UCR steelhead, or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River projects, is 1.05, ranging from no survival improvement needed up to 1.21 (Table D.55).

For the long-term (2014) proposed hydro operation, Table D.56 shows the estimated juvenile system survivals for this listed stock range from 18% up to over 66% during the study period, with a mean value of about 51%.

Thus, for UCR steelhead (and for MCR steelhead that migrate through all four lower Columbia River dams), the estimated relative gap between the proposed hydro operation and the reference operation in the long-term (2014) for in-river survival through four Columbia River FCRPS dams and reservoirs closes to -1.5%, and ranges from -16.6% to +7.9% (Figure D.15). The estimated long-term survival multiplier for UCR steelhead, or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River projects, is 1.04, ranging from no survival improvement needed up to 1.20 (Table D.56).

3.4.6 MCR Steelhead

3.4.6.1 MCR Steelhead passing from John Day reservoir through Bonneville Dam

For MCR steelhead passing through the John Day pool to Bonneville Dam in the reference operation (three projects), the estimated juvenile in-river survival rates through the lower Columbia River ranged from about 32% up to 77% during the 1994-2003 study period, with a mean value of about 60% (Table D.54). For the near-term (2004) proposed hydro operation, Table D.54 shows the estimated juvenile in-river survivals for MCR steelhead (JDA to BON) ranging from about 26% to nearly 73% during the study period, with a mean value of under 56%. For the mid-term (2010) proposed hydro operation, estimated juvenile in-river survivals for MCR steelhead ranged from about 27% up to 75% during the study period, with a mean value of over 57% (Table D.55). For the long-term (2014) proposed hydro operation, estimated juvenile in-river survivals for MCR steelhead ranged from about 27% up to about 76% during the study period, with a mean value of over 58% (Table D.56).

For MCR steelhead, the estimated relative in-river survival gap between the proposed hydro operation and the reference operation in the near term (2004) over the 10-year study period is -7.7% and ranges from -18.7% to -1.3%. The estimated survival multiplier in the near term for MCR steelhead, or the relative difference in survival between the reference operation and the proposed 2004 hydro operation for in-river survival through the lower Columbia River, is 1.10, ranging from 1.01 up to 1.23 (Table D.54).

The estimated relative gap between the proposed 2010 hydro operation and the reference operation in the intermediate-term for in-river survival over the 10-year study period is -4.5%, ranging from -16% up to +2.2%. Table D.55 shows the estimated survival multiplier for MCR steelhead (JDA to BON), or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River, is 1.06, ranging from no survival improvement needed to 1.19.

The estimated relative gap between the proposed 2014 hydro operation and the reference operation in the long term for in-river survival over the 10-year study period is -3.2%, ranging from -15% up to +5%. Table D.56 shows the estimated survival multiplier for MCR steelhead (JDA to BON), or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River, is 1.05, ranging from no survival improvement needed to 1.18.

3.4.6.2 MCR Steelhead passing from John Day Dam through Bonneville Dam

For MCR steelhead passing from John Day Dam to Bonneville Dam in the reference operation (three projects), the estimated juvenile in-river survival rates through the lower Columbia River ranged from about 44% up to over 90% during the 1994-2003 study period, with a mean value of 73% (Table D.54). For the near-term (2004) proposed hydro operation, Table D.54 shows the estimated juvenile in-river survivals for MCR steelhead (JDA Dam to BON) ranged from about 40% to 88% during the study period, with a mean value of about 70%. For the intermediate-term (2010) proposed hydro operation, estimated juvenile in-river survivals for MCR steelhead (JDA Dam to BON) ranged from about 41% up to nearly 91% during the study period, with a mean value of 72% (Table D.55).

For MCR steelhead, the estimated relative in-river survival gap between the proposed hydro operation and the reference operation in the near term (2004) over the 10-year study period is -4.7% and ranges from -10% to -1.2%. The estimated survival multiplier in the near term for MCR steelhead, or the relative difference in survival between the reference operation and the proposed 2004 hydro operation for in-river survival through the lower Columbia River, is 1.05, ranging from 1.01 up to 1.11 (Table D.54).

The estimated relative gap between the proposed 2010 hydro operation and the reference operation in the mid-term for in-river survival over the 10-year study period is -1.4%, ranging from -7.1% up to +2.4%. Table D.55 indicates that, in the intermediate term, the survival multiplier for MCR steelhead (JDA Dam to BON) is 1.02, ranging from none needed to 1.08.

The estimated relative gap between the proposed 2014 hydro operation and the reference operation in the long term for in-river survival over the 10-year study period closes to -0.1%, ranging from -6.4% up to +5.1%. Table D.56 indicates that, in the long term, MCR steelhead (JDA Dam to BON) survival multiplier is 1.00, ranging from no survival improvement needed up to 1.07.

3.4.6.3 MCR Steelhead (passing from The Dalles reservoir through Bonneville Dam)

For MCR steelhead passing from The Dalles to Bonneville Dam in the reference operation, the estimated juvenile in-river survival rates through two projects on the lower Columbia River ranged from about 45% up to about 93% during the 1994-2003 study period, with a mean value of over 75% (Table D.54). For the near-term (2004) proposed hydro operation, Table D.54 shows the estimated juvenile in-river survivals for MCR steelhead (TDA to BON) range from about 41% to over 91% during the study period, with a mean value of about 72%. For the intermediate-term (2010) proposed hydro operation, estimated juvenile in-river survivals for MCR steelhead (TDA to BON) ranged from about 42% up to 93% during the study period, with a mean value of almost 74% (Table D.55). For the long-term (2014) proposed hydro operation, estimated juvenile in-river survivals for MCR steelhead (TDA to BON) ranged from over 42% up to over 94% during the study period, with a mean value of almost 75% (Table D.56).

For MCR steelhead, Table D.54 shows the estimated relative in-river survival gap between the proposed hydro operation and the reference operation in the near term (2004) over the 10-year study period is -3.8%, ranging from -9.1% to -0.2%. The estimated survival multiplier in the near term for MCR steelhead, or the relative difference in survival between the reference operation and the proposed 2004 hydro operation for in-river survival through the lower Columbia River, is 1.04, ranging from 1.00 up to 1.10 (Table D.54).

The estimated relative gap in the intermediate-term for in-river survival over the 10-year study period between the proposed 2010 hydro operation and the reference operation is -1.9%, ranging from -7.5% up to +1.5%. Table D.55 indicates that, in 2010, the survival multiplier for MCR steelhead (JDA Dam to BON) is 1.02, with a range of no multiplier needed up to 1.08.

The estimated relative gap in the long term for in-river survival over the 10-year study period between the proposed 2014 hydro operation and the reference operation is -0.8%, ranging from -6.9% up to +3.9%. Table D.56 indicates that, in the long term, the survival multiplier for MCR steelhead (JDA Dam to BON) is 1.01, with a range of no multiplier needed up to 1.08.

3.4.7 LCR Steelhead Passing through Bonneville Dam

For LCR steelhead passing Bonneville Dam in the reference operation, the estimated juvenile in-river survival rates ranged from about 65% up to about 97% during the 1994-2003 study period, with a mean value of 86% (Table D.54). For the near-term (2004) proposed hydro operation, Table D.54 shows the estimated juvenile in-river survivals for LCR steelhead range from 61% to over 95% during the study period, with a mean value of just under 84%. For the intermediate-term (2010) proposed hydro operation, estimated juvenile in-river survivals for LCR steelhead ranged from over 61% up to almost 96% during the study period, with a mean value of over 84% (Table D.55). For the long-term (2014) proposed hydro operation, estimated juvenile in-river survivals for LCR steelhead ranged from over 61% up to over 96% during the study period, with a mean value of about 85% (Table D.56).

For LCR steelhead, Table D.54 shows the estimated relative in-river survival gap between the proposed hydro operation and the reference operation in the near term (2004) over the 10-year study period is -2.8%, ranging from -6.2% to -0.2%. The estimated survival multiplier in the near-term for LCR steelhead, or the relative difference in survival between the reference operation and the proposed 2004 hydro operation for in-river survival through Bonneville Dam, is 1.03, ranging from 1.00 up to 1.07 (Table D.54).

The estimated relative gap in the long term for in-river survival of LCR steelhead over the 10-year study period between the proposed 2010 hydro operation and the reference operation is

2.4%, ranging from -6.0% up to 0%. Table D.55 also indicates that, in 2010, the survival multiplier for LCR steelhead is 1.03, with a range of 1.00 to 1.06.

The estimated relative gap in the long-term for in-river survival of LCR steelhead over the 10-year study period between the proposed 2014 hydro operation and the reference operation is -1.8%, ranging from -5.9% up to +1.6%. Table D.56 also indicates that, in the long term, the survival multiplier for LCR steelhead is 1.02, with a range from no improvement needed up to 1.06.

Table D.54 – Summary of Estimated Survival Rates for Steelhead from 2004 Hydro Gap Analysis

Gap Analysis - Steelhead Summary Page					**Study Years**						
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2004 Proposed Hydro Operation											
SR Stlhd System Survival with Wild D	41.4%	46.2%	49.9%	50.3%	49.8%	48.8%	53.4%	50.6%	46.6%	51.5%	48.9%
SR Stlhd In-river Survival (without Transport)	7.3%	33.7%	40.7%	38.8%	42.9%	42.1%	33.5%	4.5%	37.2%	24.1%	30.5%
Total % Transported	72.5%	64.2%	73.5%	75.4%	69.2%	69.4%	93.3%	88.6%	60.5%	90.1%	75.7%
UCR Stlhd In-river Survival (4 projects)	18.3%	47.3%	57.8%	55.5%	61.6%	60.1%	54.0%	16.2%	55.5%	41.3%	46.8%
MCR Stlhd In-river Survival (JDA to BON)	26.1%	54.9%	65.9%	62.4%	72.5%	66.3%	61.2%	29.1%	66.4%	50.0%	55.5%
MCR Stlhd In-river Survival (JDA Dam to BON)	39.6%	68.4%	76.8%	73.9%	88.0%	69.3%	72.1%	79.0%	70.8%	57.7%	69.6%
MCR Stlhd In-river Survival (TDA to BON)	41.1%	71.1%	80.1%	77.5%	91.4%	72.3%	74.9%	82.1%	73.6%	60.0%	72.4%
LCR Stlhd In-river Survival (BON)	61.1%	84.6%	89.4%	88.0%	95.4%	83.8%	85.9%	89.5%	84.2%	76.1%	83.8%
Reference Operation											**Mean**
SR Stlhd System Survival with Wild D	42.8%	47.3%	50.3%	50.1%	50.8%	49.3%	53.6%	51.7%	47.9%	51.5%	49.5%
SR Stlhd In-river Survival (without Transport)	10.5%	38.2%	42.7%	39.5%	47.0%	44.3%	40.2%	6.2%	42.0%	30.2%	34.1%
Total % Transported	74.9%	61.1%	72.2%	73.8%	66.6%	67.0%	91.3%	90.6%	56.0%	88.1%	74.2%
UCR Stlhd In-river Survival (4 projects)	23.6%	53.2%	60.3%	56.3%	66.9%	62.9%	60.9%	20.6%	61.7%	48.0%	51.4%
MCR Stlhd In-river Survival (JDA to BON)	32.1%	60.1%	68.4%	63.3%	77.2%	69.0%	67.4%	35.0%	72.3%	56.4%	60.1%
MCR Stlhd In-river Survival (JDA Dam to BON)	44.0%	72.0%	78.8%	74.8%	90.4%	71.2%	76.1%	86.8%	74.4%	61.6%	73.0%
MCR Stlhd In-river Survival (TDA to BON)	45.3%	74.1%	81.4%	77.7%	93.1%	73.6%	78.3%	89.4%	76.5%	63.3%	75.3%
LCR Stlhd In-river Survival (BON)	65.1%	87.1%	90.6%	88.2%	97.1%	85.0%	88.5%	94.7%	86.5%	79.0%	86.2%
Relative Difference (Reference/Proposed)											**Geomean**
SR Stlhd System Survival with Wild D	103.4%	102.3%	100.8%	99.6%	101.9%	100.9%	100.3%	102.3%	102.8%	99.9%	101.4%
SR Stlhd In-river Survival (without Transport)	144.1%	113.5%	105.0%	101.6%	109.4%	105.3%	119.9%	136.6%	112.8%	125.3%	116.6%
UCR Stlhd In-river Survival (4 projects)	128.9%	112.4%	104.3%	101.5%	108.7%	104.7%	112.8%	126.5%	111.1%	116.2%	112.4%
MCR Stlhd In-river Survival (JDA to BON)	123.0%	109.6%	103.7%	101.4%	106.5%	104.0%	110.1%	120.2%	108.9%	112.7%	109.8%
MCR Stlhd In-river Survival (JDA Dam to BON)	111.1%	105.3%	102.7%	101.2%	102.8%	102.8%	105.5%	109.9%	105.0%	106.6%	105.2%
MCR Stlhd In-river Survival (TDA to BON)	110.0%	104.3%	101.7%	100.2%	101.8%	101.8%	104.5%	108.8%	104.0%	105.6%	104.2%
LCR Stlhd In-river Survival (BON)	106.6%	103.0%	101.3%	100.2%	101.8%	101.4%	103.1%	105.8%	102.8%	103.8%	103.0%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Stlhd System Survival with Wild D	-3.3%	-2.2%	-0.8%	0.4%	-1.9%	-0.9%	-0.3%	-2.2%	-2.8%	0.1%	-1.3%
SR Stlhd In-river Survival (without Transport)	-30.6%	-11.9%	-4.7%	-1.6%	-8.6%	-5.0%	-16.6%	-26.8%	-11.3%	-20.2%	-10.5%
UCR Stlhd In-river Survival (4 projects)	-22.4%	-11.0%	-4.1%	-1.5%	-8.0%	-4.5%	-11.4%	-21.0%	-10.0%	-13.9%	-9.1%
MCR Stlhd In-river Survival (JDA to BON)	-18.7%	-8.8%	-3.6%	-1.3%	-6.1%	-3.9%	-9.2%	-16.8%	-8.2%	-11.3%	-7.7%
MCR Stlhd In-river Survival (JDA Dam to BON)	-10.0%	-5.0%	-2.6%	-1.2%	-2.7%	-2.7%	-5.2%	-9.0%	-4.7%	-6.2%	-4.7%
MCR Stlhd In-river Survival (TDA to BON)	-9.1%	-4.1%	-1.6%	-0.2%	-1.8%	-1.7%	-4.3%	-8.1%	-3.8%	-5.3%	-3.8%
LCR Stlhd In-river Survival (BON)	-6.2%	-2.9%	-1.3%	-0.2%	-1.8%	-1.4%	-3.0%	-5.5%	-2.7%	-3.6%	-2.8%

Table D.55– Summary of Estimated Survival Rates for Steelhead from 2010 Hydro Gap Analysis

Gap Analysis - Steelhead Summary Page					**Study Years**						
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2010 Proposed Hydro Operation											
SR Stlhd System Survival with Wild D	41.4%	47.2%	50.8%	51.1%	50.7%	49.7%	53.5%	50.7%	47.8%	51.6%	49.5%
SR Stlhd In-river Survival (without Transport)	7.8%	36.3%	44.6%	42.2%	46.2%	45.4%	35.8%	4.9%	40.2%	25.8%	32.9%
Total % Transported	72.6%	65.8%	74.8%	75.8%	70.6%	70.8%	93.5%	88.8%	62.2%	90.2%	76.5%
UCR Stlhd In-river Survival (4 projects)	19.5%	50.3%	62.4%	59.1%	65.5%	64.2%	57.5%	17.5%	59.1%	44.0%	49.9%
MCR Stlhd In-river Survival (JDA to BON)	26.9%	56.7%	69.0%	64.6%	74.8%	68.5%	63.2%	30.1%	68.6%	51.7%	57.4%
MCR Stlhd In-river Survival (JDA Dam to BON)	40.9%	70.6%	80.4%	76.6%	90.9%	71.7%	74.4%	81.5%	73.1%	59.6%	72.0%
MCR Stlhd In-river Survival (TDA to BON)	41.9%	72.4%	82.4%	78.9%	93.1%	73.6%	76.3%	83.6%	75.0%	61.1%	73.8%
LCR Stlhd In-river Survival (BON)	61.2%	84.8%	90.6%	88.1%	95.7%	84.0%	86.1%	89.7%	84.4%	76.3%	84.1%
Reference Operation											**Mean**
SR Stlhd System Survival with Wild D	42.8%	47.3%	50.3%	50.1%	50.8%	49.3%	53.6%	51.7%	47.9%	51.5%	49.5%
SR Stlhd In-river Survival (without Transport)	10.5%	38.2%	42.7%	39.5%	47.0%	44.3%	40.2%	6.2%	42.0%	30.2%	34.1%
Total % Transported	74.9%	61.1%	72.2%	73.8%	66.6%	67.0%	91.3%	90.6%	56.0%	88.1%	74.2%
UCR Stlhd In-river Survival (4 projects)	23.6%	53.2%	60.3%	56.3%	66.9%	62.9%	60.9%	20.6%	61.7%	48.0%	51.4%
MCR Stlhd In-river Survival (JDA to BON)	32.1%	60.1%	68.4%	63.3%	77.2%	69.0%	67.4%	35.0%	72.3%	56.4%	60.1%
MCR Stlhd In-river Survival (JDA Dam to BON)	44.0%	72.0%	78.8%	74.8%	90.4%	71.2%	76.1%	86.8%	74.4%	61.6%	73.0%
MCR Stlhd In-river Survival (2 projects)	45.3%	74.1%	81.4%	77.7%	93.1%	73.6%	78.3%	89.4%	76.5%	63.3%	75.3%
LCR Stlhd In-river Survival (1 project)	65.1%	87.1%	90.6%	88.2%	97.1%	85.0%	88.5%	94.7%	86.5%	79.0%	86.2%
Relative Difference (Reference/Proposed)											
SR Stlhd System Survival with Wild D	103.2%	100.1%	99.0%	98.2%	100.1%	99.2%	100.1%	102.1%	100.3%	99.7%	100.2%
SR Stlhd In-river Survival (without Transport)	134.7%	105.3%	95.8%	93.6%	101.7%	97.6%	112.2%	126.3%	104.4%	117.2%	108.1%
UCR Stlhd In-river Survival (4 projects)	120.8%	105.7%	96.6%	95.2%	102.2%	98.1%	105.9%	117.4%	104.3%	109.0%	105.2%
MCR Stlhd In-river Survival (JDA to BON)	119.1%	106.2%	99.1%	97.9%	103.2%	100.6%	106.6%	116.5%	105.5%	109.2%	106.2%
MCR Stlhd In-river Survival (JDA Dam to BON)	107.7%	102.0%	98.1%	97.7%	99.5%	99.4%	102.2%	106.5%	101.7%	103.3%	101.7%
MCR Stlhd In-river Survival (TDA to BON)	108.1%	102.4%	98.8%	98.5%	99.9%	99.9%	102.6%	106.9%	102.0%	103.6%	102.2%
LCR Stlhd In-river Survival (BON)	106.3%	102.7%	100.0%	100.1%	101.5%	101.2%	102.8%	105.6%	102.5%	103.5%	102.6%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Stlhd System Survival with Wild D	-3.1%	-0.1%	1.1%	1.8%	-0.1%	0.8%	-0.1%	-2.1%	-0.3%	0.3%	-0.1%
SR Stlhd In-river Survival (without Transport)	-25.7%	-5.1%	4.3%	6.8%	-1.6%	2.5%	-10.9%	-20.8%	-4.2%	-14.7%	-3.4%
UCR Stlhd In-river Survival (4 projects)	-17.2%	-5.4%	3.5%	5.1%	-2.1%	1.9%	-5.6%	-14.8%	-4.1%	-8.3%	-2.9%
MCR Stlhd In-river Survival (JDA to BON)	-16.1%	-5.8%	0.9%	2.2%	-3.1%	-0.6%	-6.2%	-14.2%	-5.2%	-8.4%	-4.5%
MCR Stlhd In-river Survival (JDA Dam to BON)	-7.1%	-1.9%	2.0%	2.4%	0.5%	0.6%	-2.1%	-6.1%	-1.6%	-3.2%	-1.4%
MCR Stlhd In-river Survival (TDA to BON)	-7.5%	-2.3%	1.2%	1.5%	0.1%	0.1%	-2.5%	-6.5%	-2.0%	-3.5%	-1.9%
LCR Stlhd In-river Survival (BON)	-6.0%	-2.6%	0.0%	-0.1%	-1.5%	-1.1%	-2.8%	-5.3%	-2.4%	-3.4%	-2.4%

Table D.56 – Summary of Estimated Survival Rates for Steelhead from 2014 Hydro Gap Analysis

Gap Analysis - Steelhead Summary Page	Study Years										
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean
2014 Proposed Hydro Operation											
SR Stlhd System Survival with Wild D	41.5%	47.0%	50.9%	51.3%	50.9%	49.9%	53.6%	50.7%	47.7%	51.6%	49.5%
SR Stlhd In-river Survival (without Transport)	7.9%	37.0%	45.4%	43.6%	47.2%	46.7%	36.4%	5.0%	41.1%	26.1%	33.6%
Total % Transported	72.6%	62.3%	73.3%	74.7%	67.6%	68.3%	93.5%	88.8%	58.1%	90.3%	75.0%
UCR Stlhd In-river Survival (4 projects)	19.7%	50.9%	63.1%	60.8%	66.4%	65.6%	58.2%	17.6%	59.9%	44.4%	50.6%
MCR Stlhd In-river Survival (JDA to BON)	27.1%	57.3%	69.8%	66.4%	75.8%	70.0%	64.0%	30.3%	69.4%	52.1%	58.2%
MCR Stlhd In-river Survival (JDA Dam to BON)	41.2%	71.4%	81.3%	78.6%	92.0%	73.2%	75.3%	82.1%	74.1%	60.1%	72.9%
MCR Stlhd In-river Survival (TDA to BON)	42.1%	73.1%	83.2%	80.7%	94.2%	75.0%	77.0%	84.1%	75.8%	61.5%	74.7%
LCR Stlhd In-river Survival (BON)	61.3%	85.2%	91.0%	89.6%	96.3%	85.2%	86.5%	89.7%	84.9%	76.4%	84.6%
Reference Operation											**Mean**
SR Stlhd System Survival with Wild D	42.8%	47.3%	50.3%	50.1%	50.8%	49.3%	53.6%	51.7%	47.9%	51.5%	49.5%
SR Stlhd In-river Survival (without Transport)	10.5%	38.2%	42.7%	39.5%	47.0%	44.3%	40.2%	6.2%	42.0%	30.2%	34.1%
Total % Transported	74.9%	61.1%	72.2%	73.8%	66.6%	67.0%	91.3%	90.6%	56.0%	88.1%	74.2%
UCR Stlhd In-river Survival (4 projects)	23.6%	53.2%	60.3%	56.3%	66.9%	62.9%	60.9%	20.6%	61.7%	48.0%	51.4%
MCR Stlhd In-river Survival (JDA to BON)	32.1%	60.1%	68.4%	63.3%	77.2%	69.0%	67.4%	35.0%	72.3%	56.4%	60.1%
MCR Stlhd In-river Survival (JDA Dam to BON)	44.0%	72.0%	78.8%	74.8%	90.4%	71.2%	76.1%	86.8%	74.4%	61.6%	73.0%
MCR Stlhd In-river Survival (2 projects)	45.3%	74.1%	81.4%	77.7%	93.1%	73.6%	78.3%	89.4%	76.5%	63.3%	75.3%
LCR Stlhd In-river Survival (1 project)	65.1%	87.1%	90.6%	88.2%	97.1%	85.0%	88.5%	94.7%	86.5%	79.0%	86.2%
Relative Difference (Reference/Proposed)											
SR Stlhd System Survival with Wild D	103.2%	100.5%	98.7%	97.8%	99.9%	98.7%	100.0%	102.1%	100.4%	99.7%	100.1%
SR Stlhd In-river Survival (without Transport)	133.1%	103.2%	94.2%	90.6%	99.5%	94.7%	110.4%	124.8%	102.2%	115.7%	106.1%
UCR Stlhd In-river Survival (4 projects)	119.9%	104.5%	95.5%	92.7%	100.8%	96.0%	104.7%	116.5%	103.0%	108.2%	103.9%
MCR Stlhd In-river Survival (JDA to BON)	118.3%	105.0%	98.0%	95.3%	101.9%	98.5%	105.4%	115.6%	104.2%	108.3%	104.8%
MCR Stlhd In-river Survival (JDA Dam to BON)	106.9%	100.9%	97.0%	95.1%	98.3%	97.3%	101.0%	105.7%	100.4%	102.5%	100.4%
MCR Stlhd In-river Survival (TDA to BON)	107.5%	101.4%	97.9%	96.3%	98.8%	98.1%	101.6%	106.3%	101.0%	103.1%	101.1%
LCR Stlhd In-river Survival (BON)	106.3%	102.3%	99.6%	98.4%	100.9%	99.8%	102.4%	105.5%	101.9%	103.4%	102.0%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Stlhd System Survival with Wild D	-3.1%	-0.5%	1.3%	2.2%	0.1%	1.3%	0.0%	-2.0%	-0.4%	0.3%	-0.1%
SR Stlhd In-river Survival (without Transport)	-24.8%	-3.1%	6.2%	10.4%	0.5%	5.5%	-9.4%	-19.9%	-2.1%	-13.6%	-1.3%
UCR Stlhd In-river Survival (4 projects)	-16.6%	-4.3%	4.7%	7.9%	-0.8%	4.1%	-4.5%	-14.2%	-2.9%	-7.5%	-1.5%
MCR Stlhd In-river Survival (JDA to BON)	-15.4%	-4.8%	2.0%	5.0%	-1.8%	1.5%	-5.1%	-13.5%	-4.0%	-7.7%	-3.2%
MCR Stlhd In-river Survival (JDA Dam to BON)	-6.4%	-0.8%	3.1%	5.1%	1.8%	2.8%	-1.0%	-5.4%	-0.4%	-2.4%	-0.1%
MCR Stlhd In-river Survival (TDA to BON)	-6.9%	-1.4%	2.2%	3.9%	1.2%	2.0%	-1.6%	-5.9%	-1.0%	-3.0%	-0.8%
LCR Stlhd In-river Survival (BON)	-5.9%	-2.2%	0.4%	1.6%	-0.9%	0.2%	-2.3%	-5.2%	-1.9%	-3.3%	-1.8%

3.4.8 SR Fall Chinook

The estimated SIMPAS in-river survival rates for SR fall chinook resulting from the reference operation were also compared to the in-river survival rates associated with the Action Agencies' 2004, 2010, and 2014 proposed action operations. Due to the lack of empirical evidence about the effects of transportation for this listed stock, estimates of transported fish survivals were not calculated. Thus, the difference in survival identified in this gap analysis is the expected difference in in-river survival rates, representing the effects to the listed species that may be attributable to the existence of the projects (dams and reservoirs) compared to the near-term, intermediate-term and long-term proposed hydro operations and system configurations of the FCRPS projects.

The SIMPAS model includes a relationship between annual survival and annual average flow rates for all three ESUs that are directly modeled. The relationships for SR spring/summer chinook salmon and SR steelhead are based on empirical survival rates through the entire FCRPS. For SR fall chinook salmon, the relationship is based on empirical reach survival rates through the four lower Snake River projects, but empirical reach survival rates are not available through the lower Columbia River projects. The model was therefore run under two sensitivity analyses for SR fall chinook.

Under the first lower Columbia River flow/survival sensitivity analysis, the results of which are described below, the empirical reach survival estimates from the lower Snake River were extrapolated to the lower Columbia River using methods described in Attachment 3. The pool survival estimates for the reference and proposed actions were applied in SIMPAS by calculating an "adjustment factor" to the retrospective pool survival estimates from which the flow/survival relationship was calculated (Step 3 of Attachment 3, p. D3-18). It is possible that this method over-estimates reservoir mortality in the lower Columbia River, because PIT-tagged SR fall chinook salmon have a much faster migration rate through the lower Columbia than through the Snake River, so they may experience less exposure to predation.

The SIMPAS modeling results for the first sensitivity analysis is shown below in Tables D.57, D.58 and D.59 and provide an indication of the relative difference, or "gap," in in-river passage survival between the three proposed and reference operations. These relative differences in survival are calculated for each year in the eight-year study period by subtracting the reference operation in-river survival rates from the near-term and long-term proposed hydro operation survival rates and dividing the difference by the reference operation in-river survival.

Under the reference operation for SR fall chinook, Table D.57 shows that estimated juvenile in-river survivals for non-transported juvenile fish ranged from nearly 10% to almost 24% during the 1995-2001 and 2003 study period, with a mean value of 17%. For the proposed 2004 hydro operation, estimated juvenile in-river survivals for this listed stock ranged from over 8% to almost 22% during the 8-year study period, with a mean value of over 14% (Table D.57).

For SR fall chinook, the estimated relative gap between the 2004 proposed action and the reference operation over the eight-year study period for in-river survival through the FCRPS is -16.6%, and ranges from -7% to -25%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the 2004 proposed hydro operation, is 1.21 and ranges from 1.08 to 1.33 (Table D.57).

Under the proposed intermediate-term (2010) hydro operation, the estimated juvenile in-river survival rates for this listed stock ranged from 9% to almost 24% during the eight-year study period, with a mean value of over 15% (Table D.58).

For SR fall chinook, the estimated relative gap between the proposed 2010 operation and system configuration and the reference operation over the study period for in-river survival through the FCRPS is -10%, and ranges from -19% to 0%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the intermediate-term (2010) proposed hydro operation, is 1.12 and ranges from no improvement in survival needed to 1.23.

For the proposed long-term (2014) hydro operation, the estimated juvenile in-river survival rates ranged from over 9% to almost 25% during the eight-year study period, with a mean value of over 16% (Table D.59).

For SR fall chinook, the estimated relative gap between the proposed 2014 operation and system configuration and the reference operation over the study period for in-river survival through the FCRPS is -5%, and ranges from -14.5% to +5%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the long-term (2014) proposed hydro operation, is 1.07 and ranges from no survival improvement needed to 1.17.

Under the second lower Columbia River flow/survival sensitivity analysis, flow is estimated to have no effect on reservoir survival rates in the lower Columbia River. This is implemented in the SIMPAS model by setting the pool survival "adjustment factor," described above for the first sensitivity analysis, to 1.0. Results of this analysis are presented in Tables D.60, D.61, and D.62. This analysis may underestimate the mortality rate under lower flow conditions. The two sensitivity analyses are expected to largely bound the range of reservoir survival rates for SR fall chinook salmon. These sensitivity analyses are only applied to the relative differences in survival.

The results of the lower Columbia River flow/survival sensitivity analyses indicate that, under the reference operation for SR fall chinook, Table D.60 shows that estimated juvenile in-river survivals for non-transported juvenile fish ranged from 5% to 19% during the 1995-2001 and 2003 study period, with a mean value of over 15%. For the proposed 2004 hydro operation, estimated juvenile in-river survivals for this listed stock ranged from under 5% to over 18% during the 8-year study period, with a mean value of over 14% (Table D.60).

For SR fall chinook in the second sensitivity study, the estimated relative gap between the 2004 proposed action and the reference operation over the eight-year study period for in-river survival through the FCRPS is -8.4%, and ranges from -5% to -13%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the 2004 proposed hydro operation, is 1.09 and ranges from 1.06 to 1.16 (Table D.60).

Under the proposed intermediate-term (2010) hydro operation in the second sensitivity study, the estimated juvenile in-river survival rates for this listed stock ranged from 5% to almost 20% during the eight-year study period, with a mean value of over 15% (Table D.61).

For SR fall chinook, the estimated relative gap between the proposed 2010 operation and system configuration and the reference operation over the study period for in-river survival through the FCRPS is -1.2%, and ranges from -7% to +2.1%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the intermediate-term (2010) proposed hydro operation, is 1.01 and ranges from no improvement in survival needed to 1.07.

For the proposed long-term (2014) hydro operation in the second sensitivity study, the estimated juvenile in-river survival rates ranged from over 5% to almost 21% during the eight-year study period, with a mean value of just under 16% (Table D.62).

For SR fall chinook, the estimated relative survival between the proposed 2014 operation and system configuration and the reference operation over the study period for in-river survival through the FCRPS shows that the difference in survival is +4.1% and ranges from -1.5% to +7.5%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the long-term (2014) proposed hydro operation indicates that no survival improvement is needed, on average in the long term, and ranges up to 1.02 (Table D.62).

Fish placed on barges and transported are assumed to have a 98% survival rate to the point of release below Bonneville Dam. In the analyses of ESUs that are transported from collector projects, the survival rate of transported fish is adjusted by estimates of the differential survival rate of transported fish, compared to in-river migrants, below Bonneville Dam. This ratio (referred to as “D”) essentially adjusts transported and non-transported juveniles to Bonneville Dam equivalents. Empirical estimates of D in Williams *et al.* (2004) were applied to SR spring/summer chinook salmon and SR steelhead. Mean estimates based on a range of water years were applied.

Corresponding estimates for SR fall chinook are not available. Williams *et al.* (2004) suggested that, based on the range of smolt-to-adult returns (SAR) for a few relatively small groups of transported and non-transported fish in recent years, the D-value might range between 0.67 and 1.50 times the in-river survival rate. The in-river survival rate in question is that of non-transported fish from the tailrace of the collector project to the tailrace of Bonneville Dam.

Under the simplifying assumption that all transported fish are collected at Lower Granite Dam, the in-river survival rate below this point under recent conditions ranges from approximately 17-43%, depending upon water year (Appendix D, Attachment 5). If transportation from other sites were considered, the in-river survival rate would be higher (since there would be fewer downstream dams and reservoirs to pass), as would the estimated D, so this approach is conservative. When those in-river survival rates are multiplied by the low estimate of 0.67 from Williams *et al.* (2004), the resulting range of D-values is 11 to 22%, with a mean value of 18% (Appendix D, Attachment 5). When the survival rates are multiplied by the high estimate of 1.5 from Williams *et al.* (2004), the resulting range of D-values is 25 to 50%, with a mean value of 41% (Appendix D, Attachment 5).

Because the uncertainty associated with SR fall chinook D-values is great, NOAA Fisheries did not report absolute estimates of system survival (including D) for this ESU for the reference or proposed operations. However, a sensitivity analysis using the range of likely D-values was applied to the relative difference between operations in Section 6.0. Details of this sensitivity analysis are included in Appendix D, Attachment 5. For this sensitivity analysis, D = 18% to D = 41% was analyzed, since these bounds represented the mean estimates over a range of water years, for both the low and high multipliers defined in Williams *et al.* (2004).

An additional uncertainty related to evaluating the survival of fall chinook juveniles is the percentage of these fish that exhibit a subyearling vs. yearling life history. Connors documented these fish exhibit both of these life history patterns (Connor 2004). However, the range of in-river survival estimates reported in Tables 6.8 and 6.11 considered only the subyearling life history phase and did not include any additional survival that would be afforded by the yearling life history. The survival of the yearling phase of SR fall chinook would likely be much higher, because they would migrate at a larger size and under cooler water conditions in the following year. Accordingly, their survival rates would likely be closer to that of yearling SR spring/summer chinook. To estimate this effect on the SR fall chinook gap analysis, NOAA Fisheries conducted a sensitivity analysis by assuming various proportions of the fall chinook population exhibiting either the subyearling and yearling life history.

To obtain an estimate of what proportion of each life history to use, NOAA Fisheries requested the USFWS provide an estimate. In response to this request, B. Connor provided a memo with a description of the method and assumptions he used to create such estimates (B. Connor memo dated 10-29-04). The USFWS memo provided estimates of the subyearling-yearling proportions based on estimates of fish tagged in the mainstem Snake River over the last five years. The Clearwater River segment of the population, however, was not included in these estimates. Given the later migration timing of the Clearwater population, NOAA Fisheries adjusted the proportion of fish exhibiting a yearling life history phase to a 50:50 ratio as the upper end of an expected range of subyearling-yearling proportions.

If, for example, it is assumed that 25% of the SR fall chinook juveniles over-winter and then out-migrate the following spring (with a survival rate similar to that of SR spring/summer chinook), the upper end of the estimated in-river survival gap in 2004 for these fish would be reduced from 16.6% to a new value of about 14%. Similarly, assuming 50% of SR fall chinook juveniles over-winter and migrate out the following spring results in an estimated in-river survival gap of 12%.

Modeling Scenario	Relative survival Difference (%)		
	Year 2004	Year 2010	Year 2014
As modeled (100%) subyearling life history	16.6	10.0	5.0
75% subyearling and 25% yearling life history	14.3	7.5	3.0
50% subyearling and 50% yearling life history	12.0	5.0	0.6

3.4.9 LCR Fall Chinook

Under the reference operation for LCR fall chinook passing Bonneville Dam, Table D.57 shows that estimated juvenile in-river survivals ranged from about 80% to almost 98% during the 1995-2001 and 2003 study period, with a mean value of over 88%. For the proposed 2004 hydro operation, estimated juvenile in-river survivals for this listed stock ranged from about 77% to over 97% during the eight-year study period, with a mean value of 86% (Table D.57).

For LCR fall chinook, Table D.57 shows the estimated relative gap over the eight-year study period for in-river survival through the FCRPS between the 2004 proposed action and the reference operation is -2.7% and ranges from -0.2% to -4.4%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the 2004 proposed hydro operation, is 1.03 and ranges from 1.00 to 1.05% (Table D.57).

Under both the proposed intermediate- and long-term (2010 and 2014) hydro operation and system configuration, the estimated juvenile in-river survival rates for this listed stock ranged from under 77% to over 97% during the 8-year study period, with a mean value of about 86% (Tables D.58 and D.59). These tables show the estimated relative gap over the eight-year study period for in-river survival of LCR chinook through the FCRPS between both the 2010 and 2014 proposed action and the reference operation is -2.6% and ranges from -0.1% to -4.3%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the 2010 proposed hydro operation, is 1.03 and ranges from 1.00 to 1.05% (Tables D.58 and D.59).

Table D.57 – Summary of Estimated Survival Rates for Fall Chinook from 2004 Hydro Gap Analysis, assuming a flow-survival relationship in the lower Columbia River.

Gap Analysis - Subyearling Chinook Summary Page

	Study Years										
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean
2004 Proposed Hydro Operation											
SR Fall Chinook In-river Survival (without Transport)		11.3%	18.2%	21.9%	12.7%	15.9%	12.9%	8.4%		12.2%	14.2%
Total % Transported		55.5%	44.9%	40.8%	48.2%	57.5%	43.3%	21.2%		46.2%	44.7%
LCR Fall Chinook In-river Survival (1 project)		76.7%	87.7%	97.2%	80.5%	85.0%	83.4%	95.9%		81.7%	86.0%
Reference Operation											**Mean**
SR Fall Chinook In-river Survival (without Transport)		13.8%	20.9%	23.6%	16.0%	18.7%	17.2%	9.8%		16.2%	17.0%
Total % Transported		55.6%	44.5%	40.4%	48.3%	57.1%	44.5%	21.2%		47.7%	44.9%
LCR Fall Chinook In-river Survival (1 project)		79.8%	89.6%	97.4%	84.1%	87.0%	87.2%	97.6%		84.7%	88.4%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Fall Chinook In-river Survival (without Transport)		2.5%	2.7%	1.7%	3.3%	2.8%	4.3%	1.4%		4.0%	2.8%
Total % Transported		0.1%	-0.4%	-0.3%	0.1%	-0.4%	1.2%	0.0%		1.5%	0.2%
LCR Fall Chinook In-river Survival (1 project)		3.1%	1.9%	0.2%	3.5%	2.0%	3.8%	1.7%		3.1%	2.4%
Relative Difference (Reference/Proposed)											**Geomean**
SR Fall Chinook In-river Survival (without Transport)		121.8%	114.8%	107.6%	125.7%	117.5%	133.1%	117.0%		132.7%	121.0%
LCR Fall Chinook In-river Survival (1 project)		104.0%	102.2%	100.2%	104.4%	102.3%	104.6%	101.8%		103.7%	102.9%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Fall Chinook In-river Survival (without Transport)		-17.9%	-12.9%	-7.1%	-20.5%	-14.9%	-24.9%	-14.6%		-24.6%	-16.6%
LCR Fall Chinook In-river Survival (1 project)		-3.9%	-2.1%	-0.2%	-4.2%	-2.3%	-4.4%	-1.7%		-3.6%	-2.7%

Table D.58– Summary of Estimated Survival Rates for Fall Chinook from 2010 Hydro Gap Analysis, assuming a flow-survival relationship in the lower Columbia River.

Gap Analysis - Subyearling Chinook Summary Page

	Study Years										
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2010 Proposed Hydro Operation											
SR Fall Chinook In-river Survival (without Transport)		12.2%	19.6%	23.6%	13.8%	17.1%	13.9%	9.0%		13.2%	15.3%
Total % Transported		55.7%	45.1%	40.9%	48.4%	57.7%	43.5%	21.3%		46.4%	44.9%
LCR Fall Chinook In-river Survival (1 project)		76.8%	87.8%	97.3%	80.6%	85.1%	83.5%	96.0%		81.7%	86.1%
Reference Operation											**Mean**
SR Fall Chinook In-river Survival (without Transport)		13.8%	20.9%	23.6%	16.0%	18.7%	17.2%	9.8%		16.2%	17.0%
Total % Transported		55.6%	44.5%	40.4%	48.3%	57.1%	44.5%	21.2%		47.7%	44.9%
LCR Fall Chinook In-river Survival (1 project)		79.8%	89.6%	97.4%	84.1%	87.0%	87.2%	97.6%		84.7%	88.4%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Fall Chinook In-river Survival (without Transport)		1.6%	1.3%	0.0%	2.3%	1.5%	3.2%	0.8%		3.0%	1.7%
Total % Transported		-0.1%	-0.6%	-0.5%	-0.1%	-0.6%	1.0%	-0.1%		1.3%	0.0%
LCR Fall Chinook In-river Survival (1 project)		3.0%	1.8%	0.1%	3.5%	1.9%	3.8%	1.6%		3.0%	2.3%
Relative Difference (Reference/Proposed)											**Geomean**
SR Fall Chinook In-river Survival (without Transport)		112.7%	106.6%	100.0%	116.4%	109.0%	123.2%	108.5%		122.9%	112.2%
LCR Fall Chinook In-river Survival (1 project)		103.9%	102.1%	100.1%	104.3%	102.2%	104.5%	101.7%		103.7%	102.8%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Fall Chinook In-river Survival (without Transport)		-11.3%	-6.2%	0.0%	-14.1%	-8.3%	-18.9%	-7.8%		-18.6%	-10.0%
LCR Fall Chinook In-river Survival (1 project)		-3.8%	-2.0%	-0.1%	-4.1%	-2.2%	-4.3%	-1.7%		-3.5%	-2.6%

Table D.59 – Summary of Estimated Survival Rates for Fall Chinook from 2014 Hydro Gap Analysis, assuming a flow-survival relationship in the lower Columbia River.

Gap Analysis - Subyearling Chinook Summary Page

	Study Years										
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2014 Proposed Hydro Operation											
SR Fall Chinook In-river Survival (without Transport)		12.9%	20.7%	24.9%	14.5%	18.0%	14.7%	9.5%		13.9%	16.1%
Total % Transported		55.8%	45.2%	41.0%	48.5%	57.8%	43.6%	21.3%		46.5%	45.0%
LCR Fall Chinook In-river Survival (1 project)		76.8%	87.8%	97.3%	80.6%	85.1%	83.5%	96.0%		81.8%	86.1%
Reference Operation											**Mean**
SR Fall Chinook In-river Survival (without Transport)		13.8%	20.9%	23.6%	16.0%	18.7%	17.2%	9.8%		16.2%	17.0%
Total % Transported		55.6%	44.5%	40.4%	48.3%	57.1%	44.5%	21.2%		47.7%	44.9%
LCR Fall Chinook In-river Survival (1 project)		79.8%	89.6%	97.4%	84.1%	87.0%	87.2%	97.6%		84.7%	88.4%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Fall Chinook In-river Survival (without Transport)		0.9%	0.2%	-1.2%	1.5%	0.6%	2.5%	0.3%		2.3%	0.9%
Total % Transported		-0.2%	-0.7%	-0.5%	-0.2%	-0.7%	0.9%	-0.1%		1.3%	0.0%
LCR Fall Chinook In-river Survival (1 project)		3.0%	1.8%	0.1%	3.5%	1.9%	3.7%	1.6%		3.0%	2.3%
Relative Difference (Reference/Proposed)											**Geomean**
SR Fall Chinook In-river Survival (without Transport)		107.0%	101.2%	95.0%	110.5%	103.5%	117.0%	103.0%		116.7%	106.5%
LCR Fall Chinook In-river Survival (1 project)		103.9%	102.0%	100.1%	104.3%	102.2%	104.5%	101.7%		103.6%	102.8%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Fall Chinook In-river Survival (without Transport)		-6.5%	-1.1%	5.3%	-9.5%	-3.4%	-14.5%	-2.9%		-14.3%	-5.2%
LCR Fall Chinook In-river Survival (1 project)		-3.8%	-2.0%	-0.1%	-4.1%	-2.2%	-4.3%	-1.7%		-3.5%	-2.6%

Table D.60 – Summary of Estimated Survival Rates for Fall Chinook from 2004 Hydro Gap Analysis, assuming no flow-survival relationship in the lower Columbia River.

Gap Analysis - Subyearling Chinook Summary Page

	Study Years										
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2004 Proposed Hydro Operation											
SR Fall Chinook In river Survival (without Transport)		11.4%	17.8%	14.7%	18.2%	13.2%	16.0%	4.8%		15.7%	14.0%
Total % Transported		55.5%	44.9%	40.7%	48.4%	57.5%	43.4%	21.1%		46.3%	44.7%
LCR Fall Chinook In river Survival (1 project)		76.9%	86.9%	87.2%	88.5%	80.9%	88.2%	82.0%		87.2%	84.7%
Reference Operation											**Mean**
SR Fall Chinook In river Survival (without Transport)		12.2%	19.1%	15.8%	19.5%	14.3%	17.9%	5.1%		18.1%	15.2%
Total % Transported		55.6%	44.5%	40.4%	48.4%	57.1%	44.5%	21.1%		47.8%	44.9%
LCR Fall Chinook In river Survival (1 project)		76.9%	87.1%	87.4%	88.6%	81.0%	88.3%	82.1%		87.4%	84.8%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Fall Chinook In river Survival (without Transport)		0.7%	1.4%	1.1%	1.3%	1.1%	2.0%	0.3%		2.4%	1.3%
Total % Transported		0.1%	-0.4%	-0.3%	0.0%	-0.4%	1.1%	0.0%		1.5%	0.2%
LCR Fall Chinook In river Survival (1 project)		-0.1%	0.2%	0.2%	0.1%	0.2%	0.1%	0.1%		0.1%	0.1%
Relative Difference (Reference/Proposed)											**Geomean**
SR Fall Chinook In river Survival (without Transport)		106.3%	107.9%	107.6%	106.9%	108.3%	112.3%	105.7%		115.5%	108.8%
LCR Fall Chinook In river Survival (1 project)		99.9%	100.2%	100.2%	100.2%	100.2%	100.1%	100.1%		100.1%	100.1%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Fall Chinook In river Survival (without Transport)		-5.9%	-7.3%	-7.1%	-6.4%	-7.6%	-10.9%	-5.4%		-13.4%	-0.8%
LCR Fall Chinook In river Survival (1 project)		0.1%	-0.2%	-0.2%	-0.2%	-0.2%	-0.1%	-0.1%		-0.1%	-0.1%

Table D.61– Summary of Estimated Survival Rates for Fall Chinook from 2010 Hydro Gap Analysis, assuming no flow-survival relationship in the lower Columbia River.

Gap Analysis - Subyearling Chinook Summary Page

	Study Years										
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2010 Proposed Hydro Operation											
SR Fall Chinook In river Survival (without Transport)		12.4%	19.1%	15.8%	19.7%	14.2%	17.2%	5.2%		16.9%	15.1%
Total % Transported		55.7%	45.1%	40.8%	48.6%	57.7%	43.5%	21.2%		46.5%	44.9%
LCR Fall Chinook In river Survival (1 project)		77.0%	87.0%	87.3%	88.5%	81.0%	88.3%	82.1%		87.3%	84.8%
Reference Operation											**Mean**
SR Fall Chinook In river Survival (without Transport)		12.2%	19.1%	15.8%	19.5%	14.3%	17.9%	5.1%		18.1%	15.2%
Total % Transported		55.6%	44.5%	40.4%	48.4%	57.1%	44.5%	21.1%		47.8%	44.9%
LCR Fall Chinook In river Survival (1 project)		76.9%	87.1%	87.4%	88.6%	81.0%	88.3%	82.1%		87.4%	84.8%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Fall Chinook In river Survival (without Transport)		-0.2%	-0.0%	-0.0%	-0.2%	0.1%	0.7%	-0.1%		1.2%	0.2%
Total % Transported		-0.1%	-0.6%	-0.5%	-0.2%	-0.6%	0.9%	-0.1%		1.3%	0.0%
LCR Fall Chinook In river Survival (1 project)		-0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%		0.1%	0.0%
Relative Difference (Reference/Proposed)											**Geomean**
SR Fall Chinook In river Survival (without Transport)		98.4%	100.1%	100.0%	98.9%	100.4%	104.0%	98.0%		107.0%	100.8%
LCR Fall Chinook In river Survival (1 project)		99.8%	100.1%	100.1%	100.1%	100.1%	100.1%	100.0%		100.1%	100.0%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Fall Chinook In river Survival (without Transport)		1.7%	-0.1%	0.0%	1.1%	-0.4%	-3.8%	2.1%		-6.5%	-1.2%
LCR Fall Chinook In river Survival (1 project)		0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%		-0.1%	0.0%

Table D.62 – Summary of Estimated Survival Rates for Fall Chinook from 2014 Hydro Gap Analysis, assuming no flow-survival relationship in the lower Columbia River.

Gap Analysis - Subyearling Chinook Summary Page

	Study Years										
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2014 Proposed Hydro Operation											
SR Fall Chinook In river Survival (without Transport)		13.0%	20.1%	16.6%	20.7%	15.0%	18.2%	5.5%		17.8%	15.9%
Total % Transported		55.8%	45.2%	40.9%	48.6%	57.8%	43.6%	21.2%		46.6%	45.0%
LCR Fall Chinook In river Survival (1 project)		77.0%	87.0%	87.3%	88.6%	81.0%	88.3%	82.1%		87.3%	84.8%
Reference Operation											**Mean**
SR Fall Chinook In river Survival (without Transport)		12.2%	19.1%	15.8%	19.5%	14.3%	17.9%	5.1%		18.1%	15.2%
Total % Transported		55.6%	44.5%	40.4%	48.4%	57.1%	44.5%	21.1%		47.8%	44.9%
LCR Fall Chinook In river Survival (1 project)		76.9%	87.1%	87.4%	88.6%	81.0%	88.3%	82.1%		87.4%	84.8%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Fall Chinook In river Survival (without Transport)		-0.9%	-1.0%	-0.8%	-1.3%	-0.7%	-0.2%	-0.4%		0.3%	-0.6%
Total % Transported		-0.2%	-0.7%	-0.5%	-0.3%	-0.7%	0.9%	-0.1%		1.2%	-0.1%
LCR Fall Chinook In river Survival (1 project)		-0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%		0.0%	0.0%
Relative Difference (Reference/Proposed)											**Geomean**
SR Fall Chinook In river Survival (without Transport)		93.4%	95.1%	95.0%	93.9%	95.3%	98.7%	93.0%		101.6%	95.7%
LCR Fall Chinook In river Survival (1 project)		99.8%	100.1%	100.1%	100.1%	100.1%	100.0%	100.0%		100.0%	100.0%
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Fall Chinook In river Survival (without Transport)		7.1%	5.2%	5.3%	6.5%	4.9%	1.3%	7.5%		-1.5%	4.1%
LCR Fall Chinook In river Survival (1 project)		0.2%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%		0.0%	0.0%

3.5 ADULT PASSAGE SURVIVAL RATES UNDER THE PROPOSED ACTION AND REFERENCE OPERATION

No reduction in adult fish passage survival through the mainstem FCRPS projects is expected for SR spring/summer chinook and UCR spring chinook salmon, SR and UCR steelhead, and SR fall chinook salmon as a result of discretionary hydro operations under the proposed action or under the reference operation (Attachment 4).

Figure D.1 – Relative System Survival Gap for Snake River Yearling Chinook Salmon

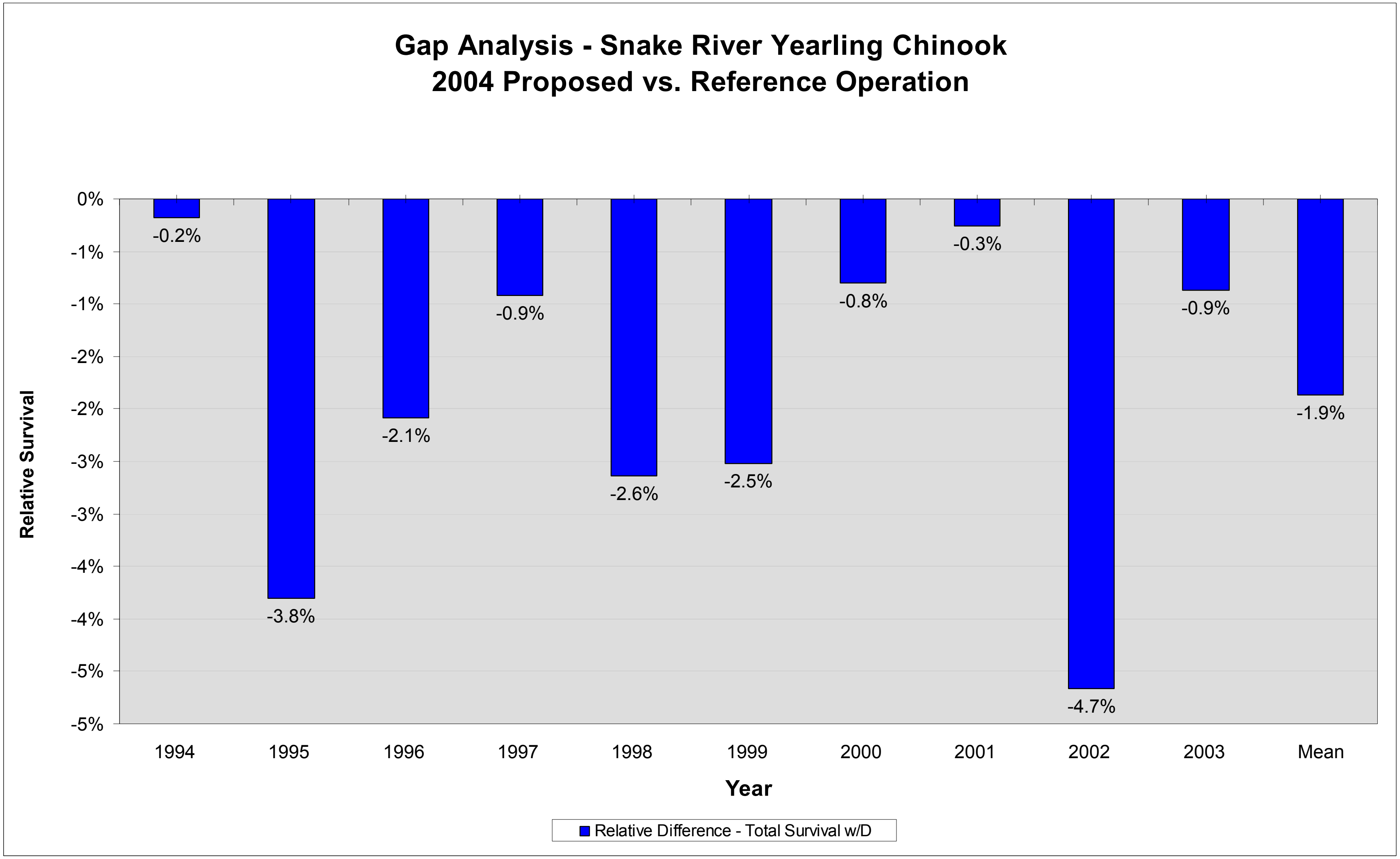


Figure D.2.

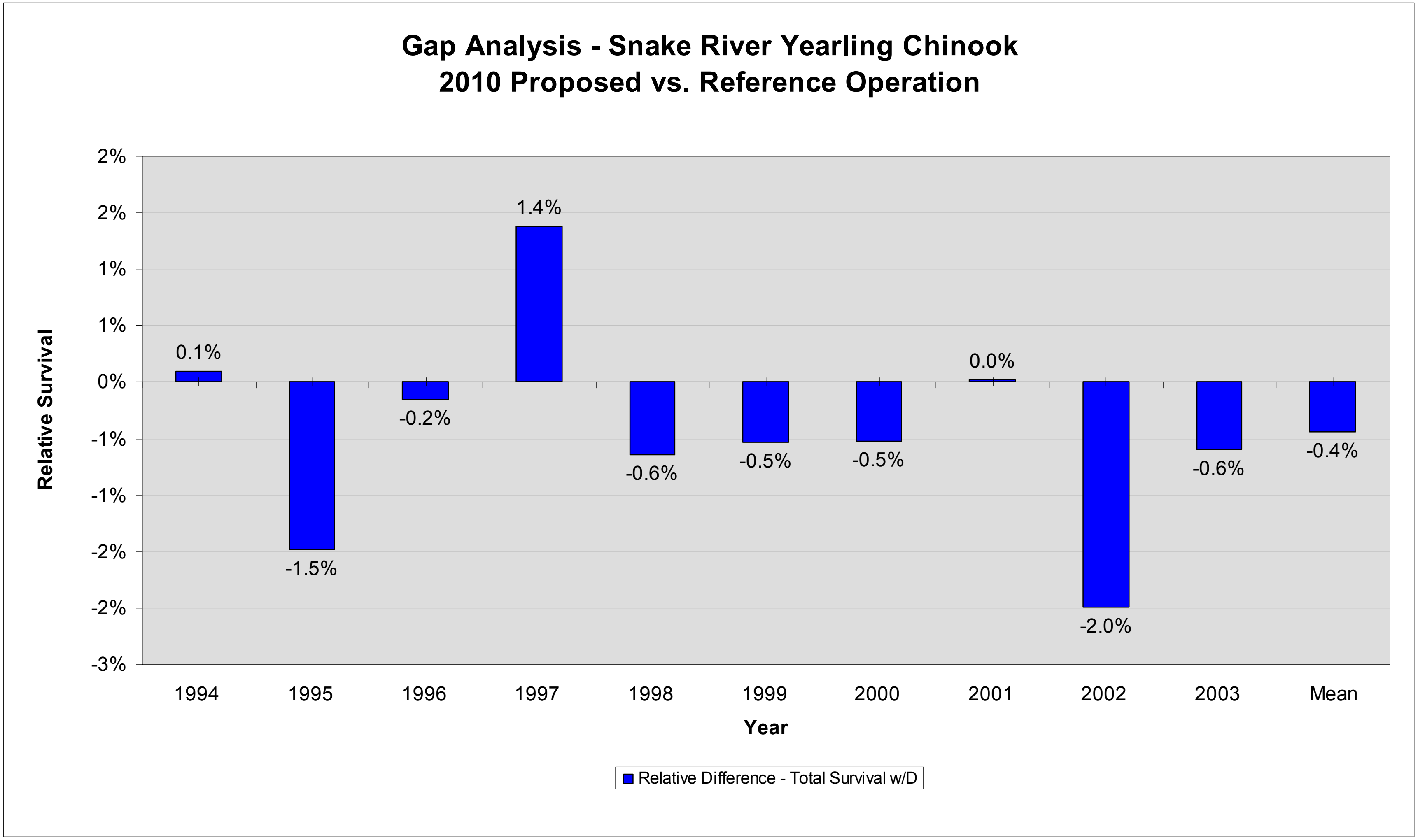

Gap Analysis - Snake River Yearling Chinook
2010 Proposed vs. Reference Operation
Relative Survival
2%
2%
1%
1%
0%
-1%
-1%
-2%
-2%
-3%
0.1%
-1.5%
-0.2%
1.4%
-0.6%
-0.5%
-0.5%
0.0%
-2.0%
-0.6%
-0.4%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival w/D

Figure D.3

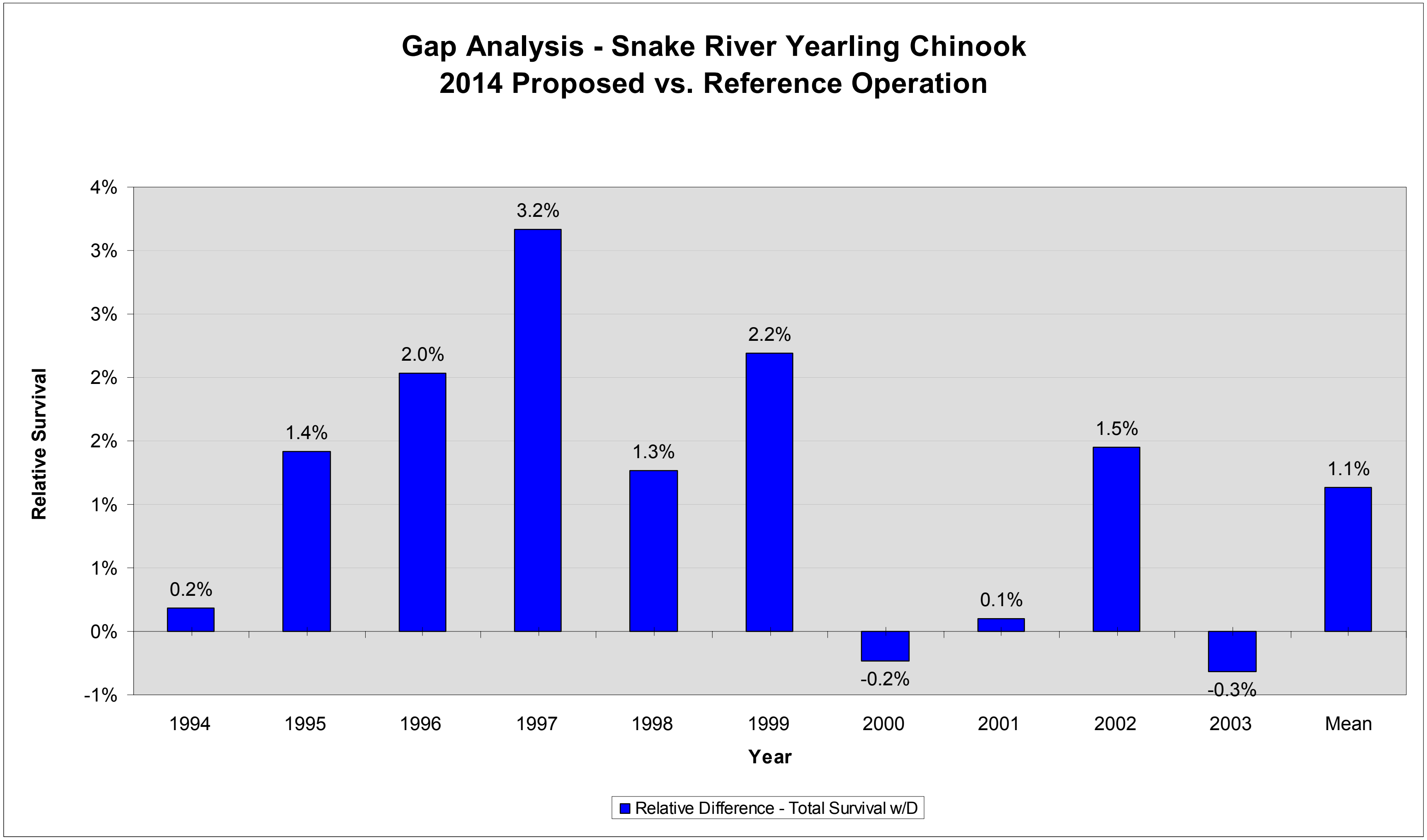

Gap Analysis - Snake River Yearling Chinook
2014 Proposed vs. Reference Operation
4%
3%
3%
2%
2%
1%
1%
0%
-1%
Relative Survival
3.2%
2.0%
2.2%
1.4%
1.3%
1.5%
1.1%
0.2%
0.1%
-0.2%
-0.3%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival w/D

Figure D.4 - Relative System Survival Gap for Snake River Steelhead

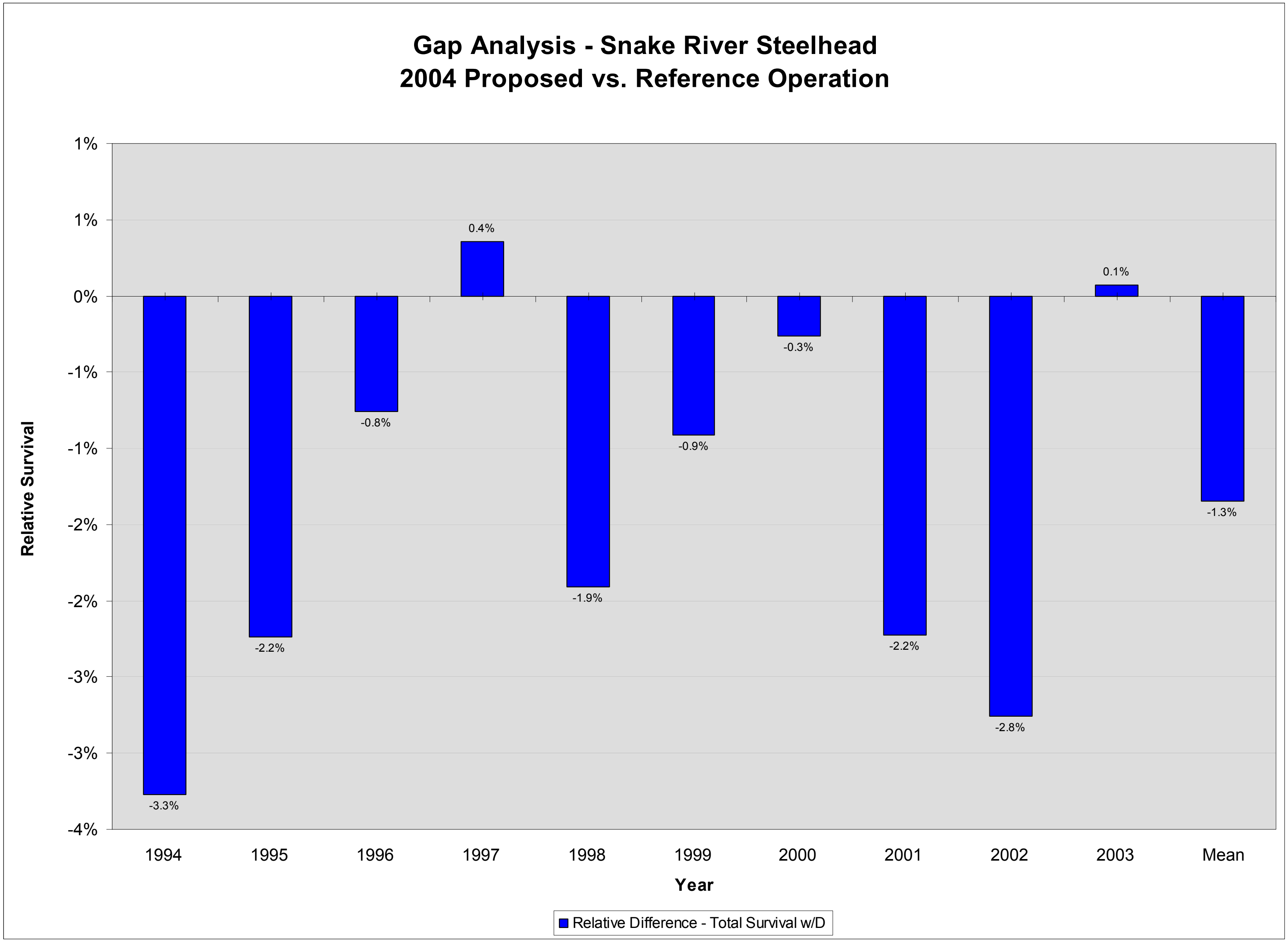
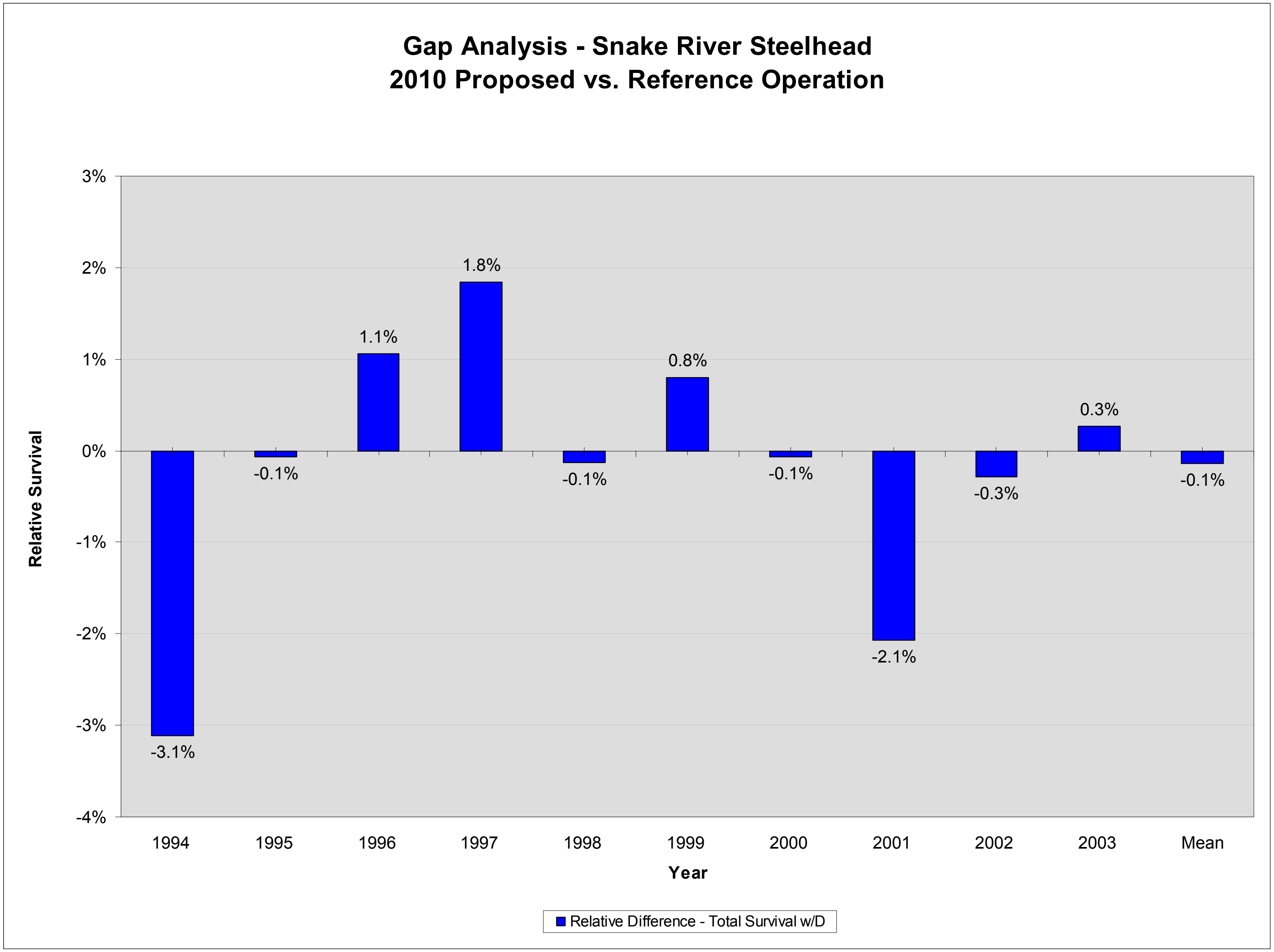


Figure D.5



Gap Analysis - Snake River Steelhead
2010 Proposed vs. Reference Operation
3%
2%
1%
0%
-1%
-2%
-3%
-4%
Relative Survival
-3.1%
-0.1%
1.1%
1.8%
-0.1%
0.8%
-0.1%
-2.1%
-0.3%
0.3%
-0.1%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival w/D

Figure D.6

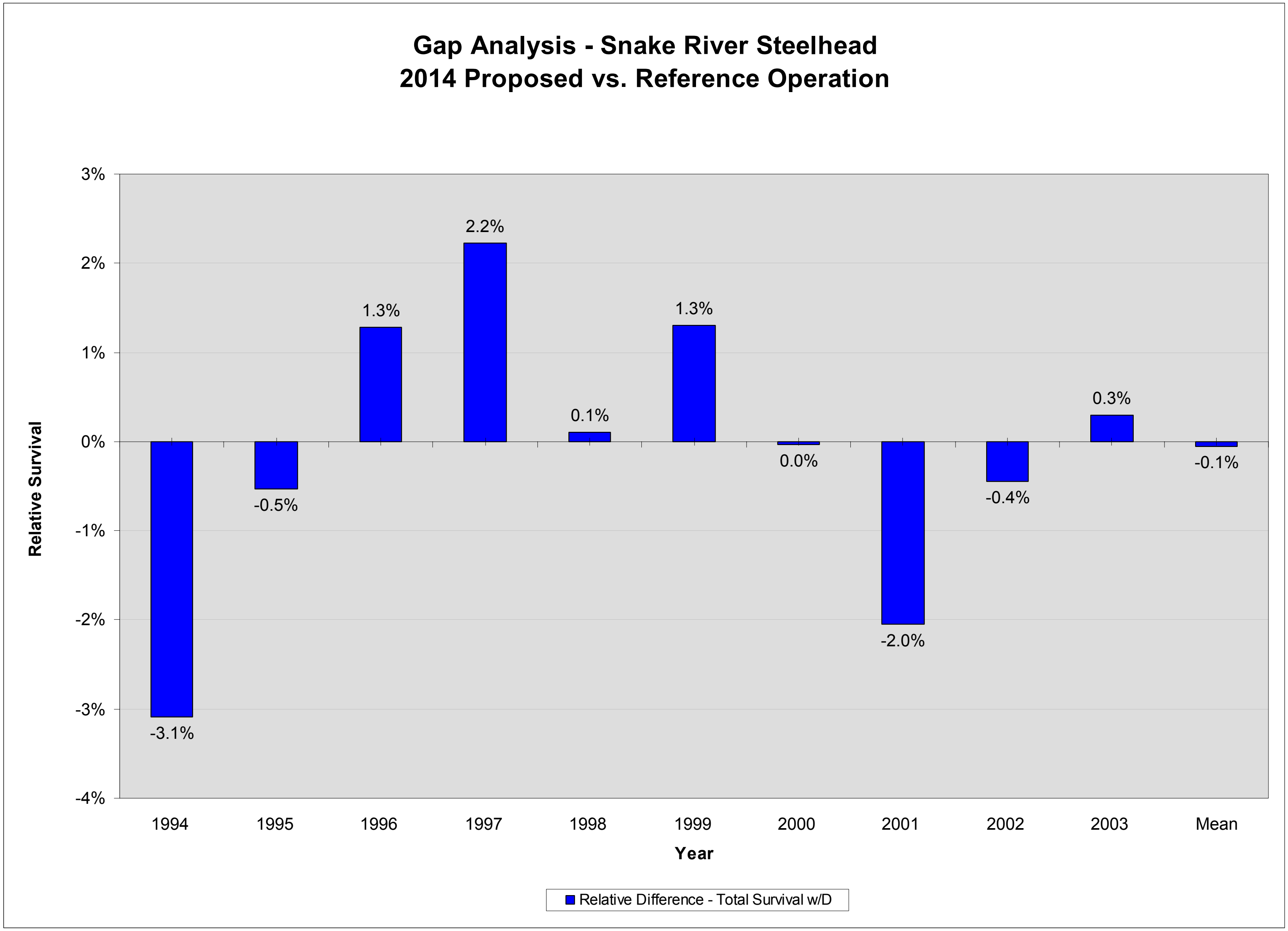

Gap Analysis - Snake River Steelhead
2014 Proposed vs. Reference Operation
3%
2%
1%
0%
-1%
-2%
-3%
-4%
Relative Survival
-3.1%
-0.5%
1.3%
2.2%
0.1%
1.3%
0.0%
-2.0%
-0.4%
0.3%
-0.1%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival w/D

Figure D.7 - Relative System Survival Gap (Without Transportation) for Snake River Subyearling Chinook Salmon

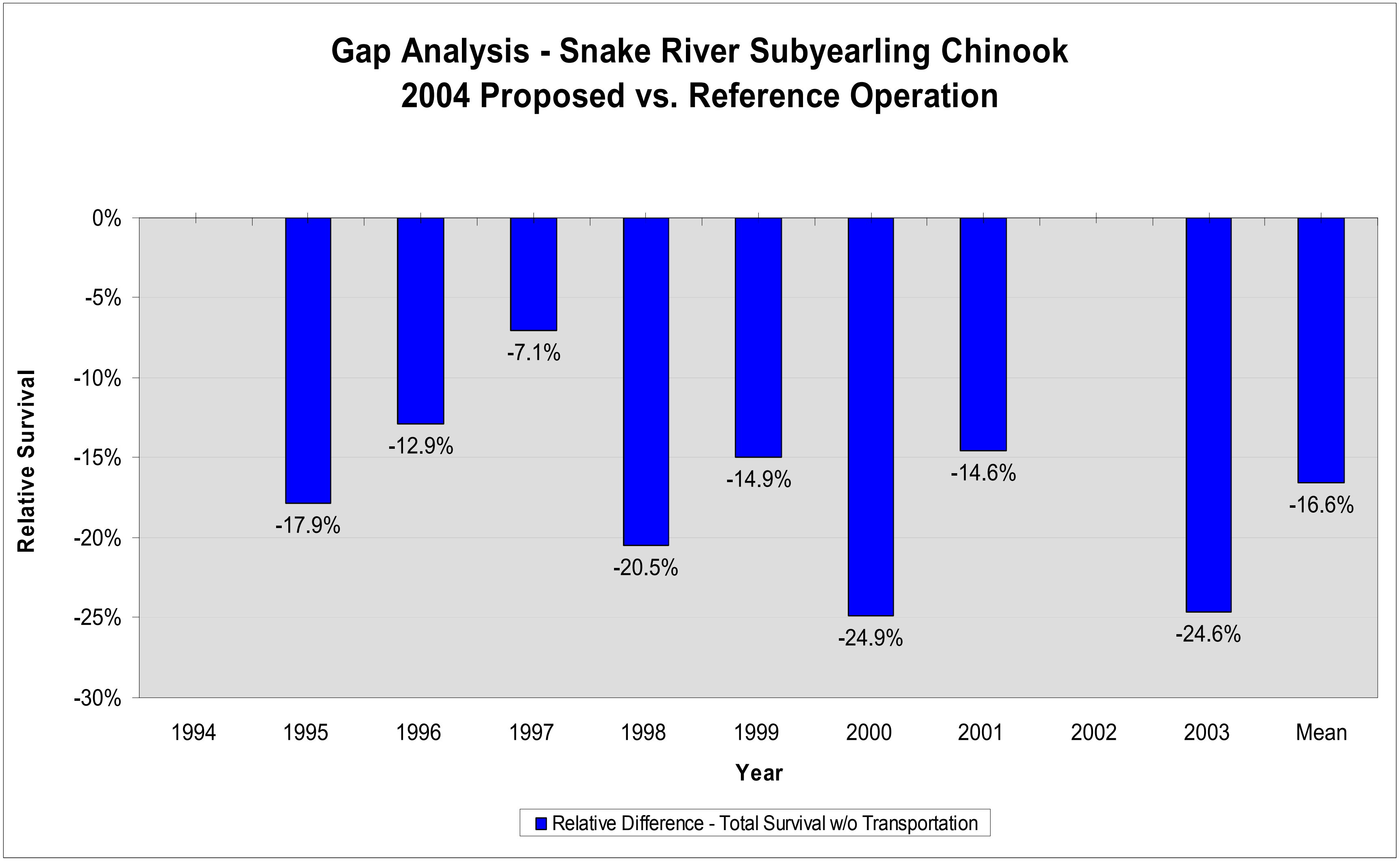


Figure D.8

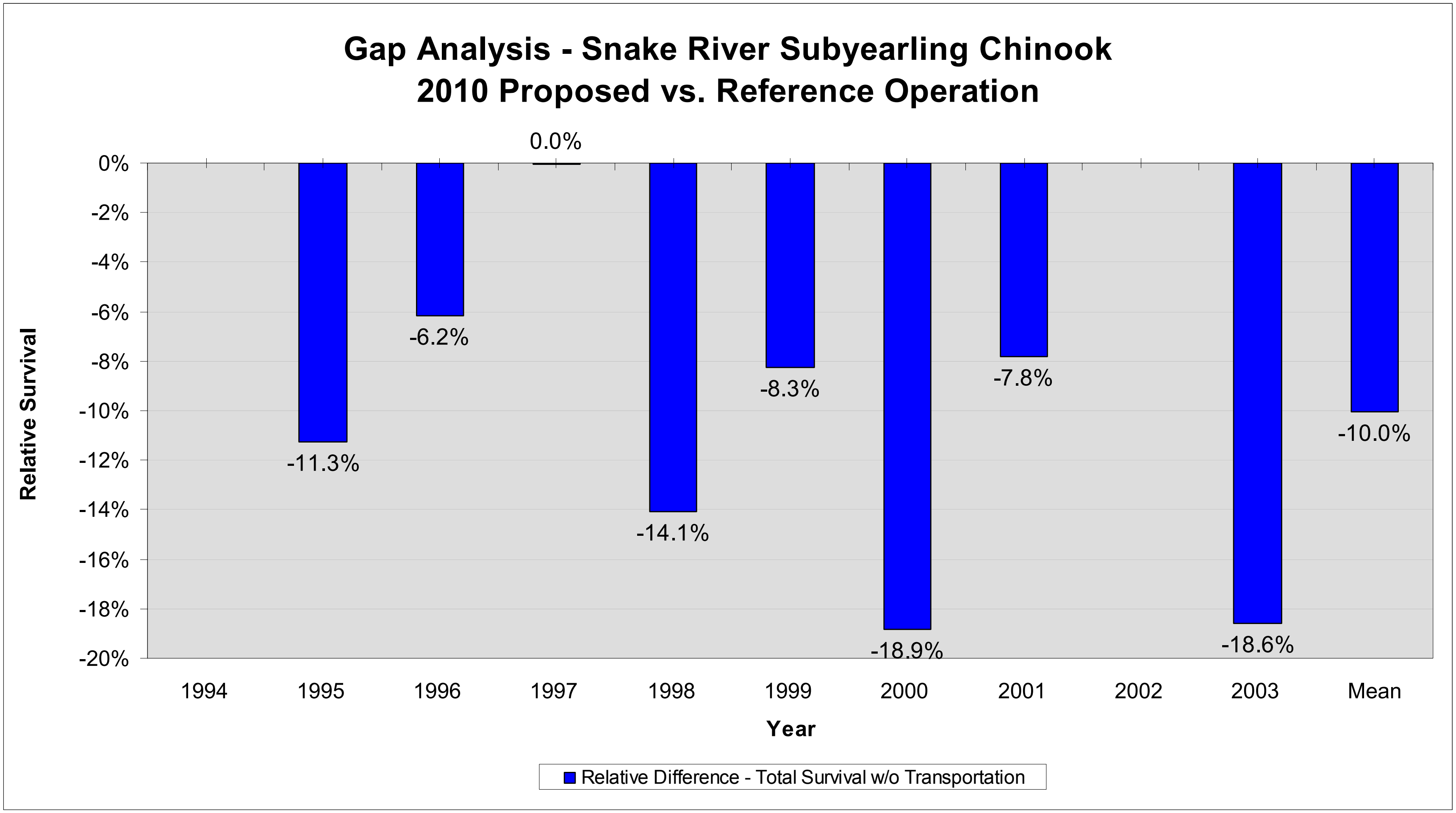

Gap Analysis - Snake River Subyearling Chinook
2010 Proposed vs. Reference Operation
Relative Survival
0%
-2%
-4%
-6%
-8%
-10%
-12%
-14%
-16%
-18%
-20%
0.0%
-11.3%
-6.2%
-14.1%
-8.3%
-18.9%
-7.8%
-18.6%
-10.0%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival w/o Transportation

Figure D.9

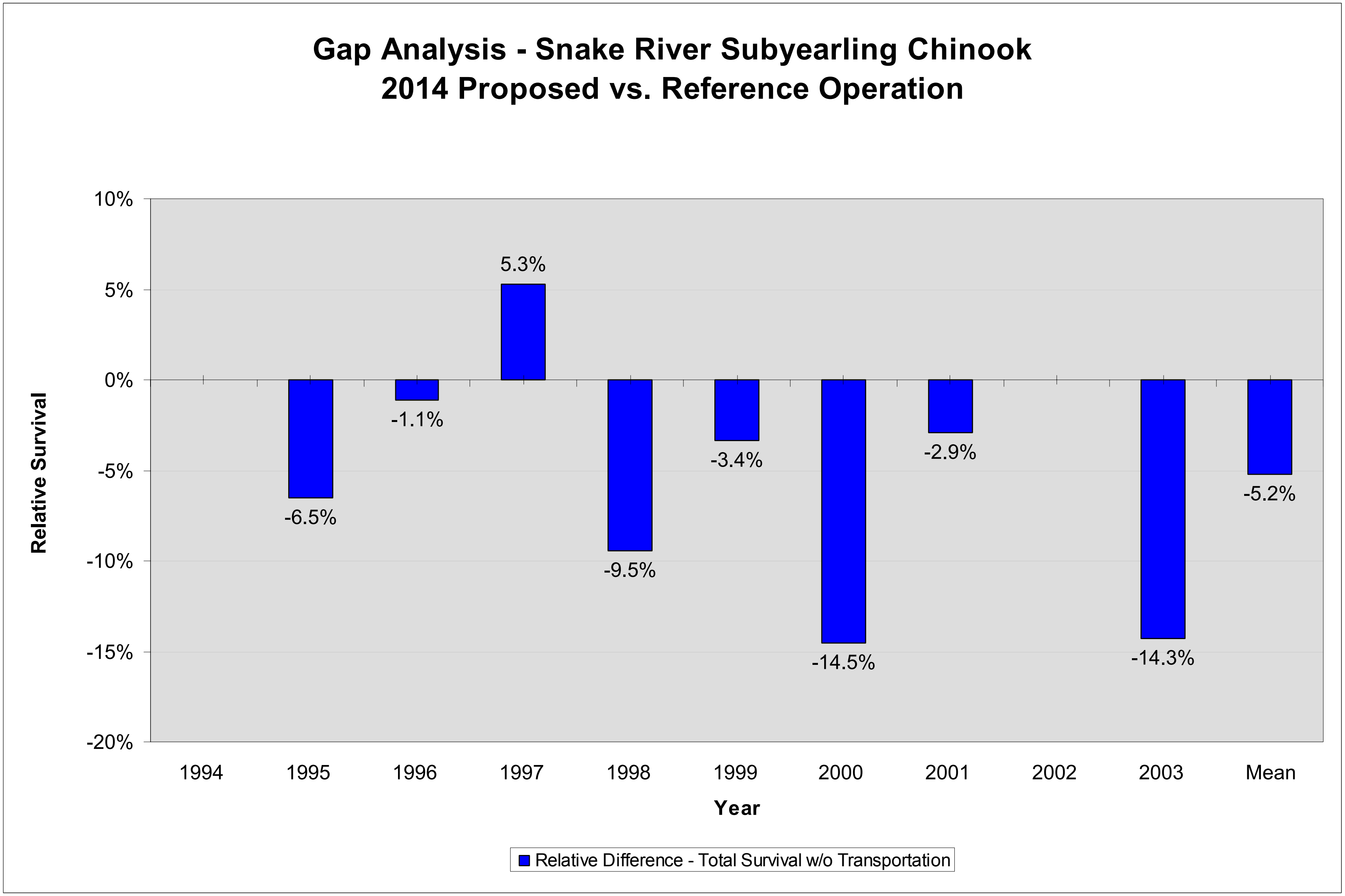

Gap Analysis - Snake River Subyearling Chinook
2014 Proposed vs. Reference Operation
10%
5%
0%
-5%
-10%
-15%
-20%
Relative Survival
5.3%
-1.1%
-6.5%
-9.5%
-3.4%
-14.5%
-2.9%
-14.3%
-5.2%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival w/o Transportation

Figure D.10

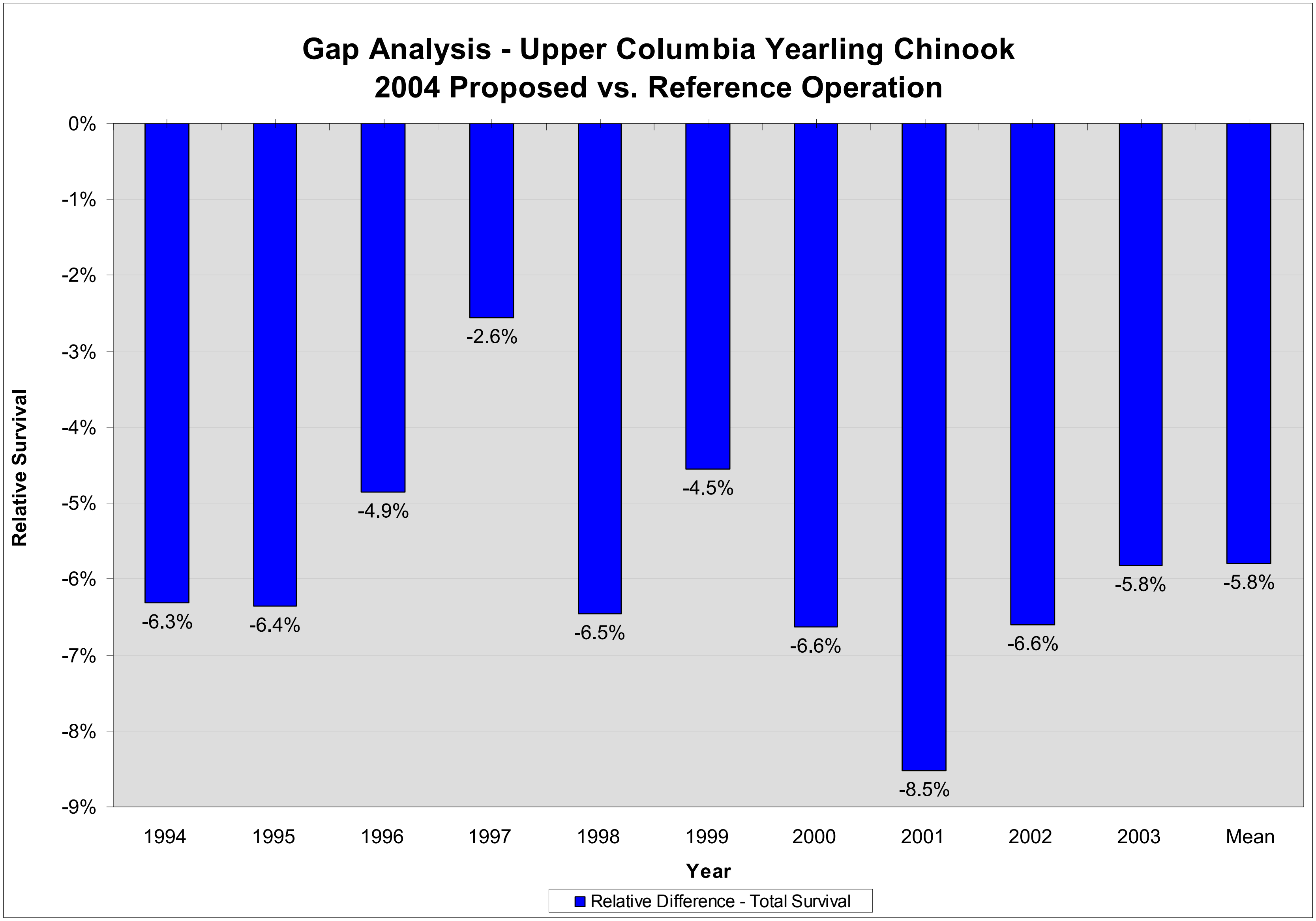

Gap Analysis - Upper Columbia Yearling Chinook
2004 Proposed vs. Reference Operation
Relative Survival
0%
-1%
-2%
-3%
-4%
-5%
-6%
-7%
-8%
-9%
-6.3%
-6.4%
-4.9%
-2.6%
-6.5%
-4.5%
-6.6%
-8.5%
-6.6%
-5.8%
-5.8%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival

Figure D.11

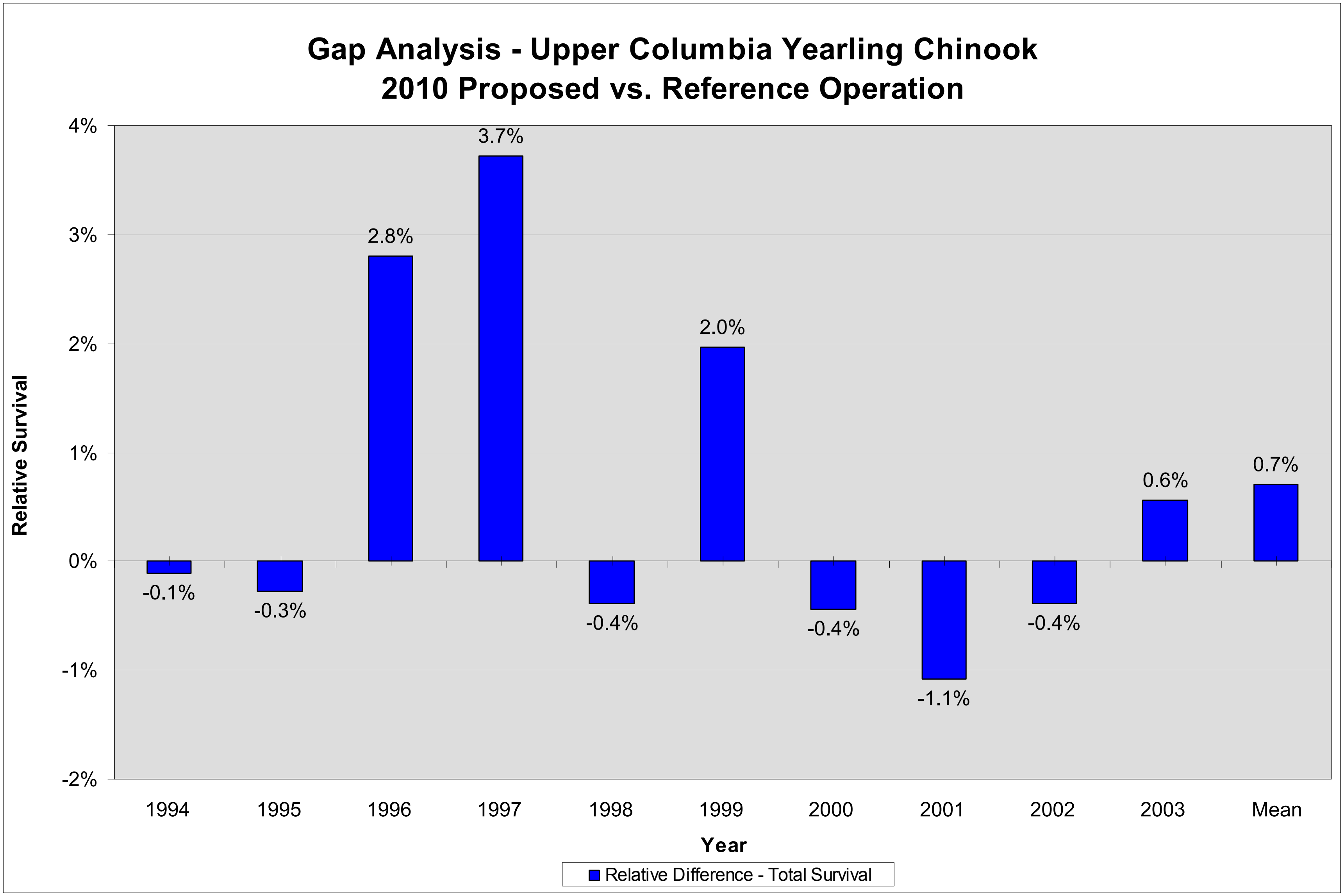

Gap Analysis - Upper Columbia Yearling Chinook
2010 Proposed vs. Reference Operation
4%
3%
2%
1%
0%
-1%
-2%
Relative Survival
3.7%
2.8%
2.0%
0.6%
0.7%
-0.1%
-0.3%
-0.4%
-0.4%
-1.1%
-0.4%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival

Figure D.12

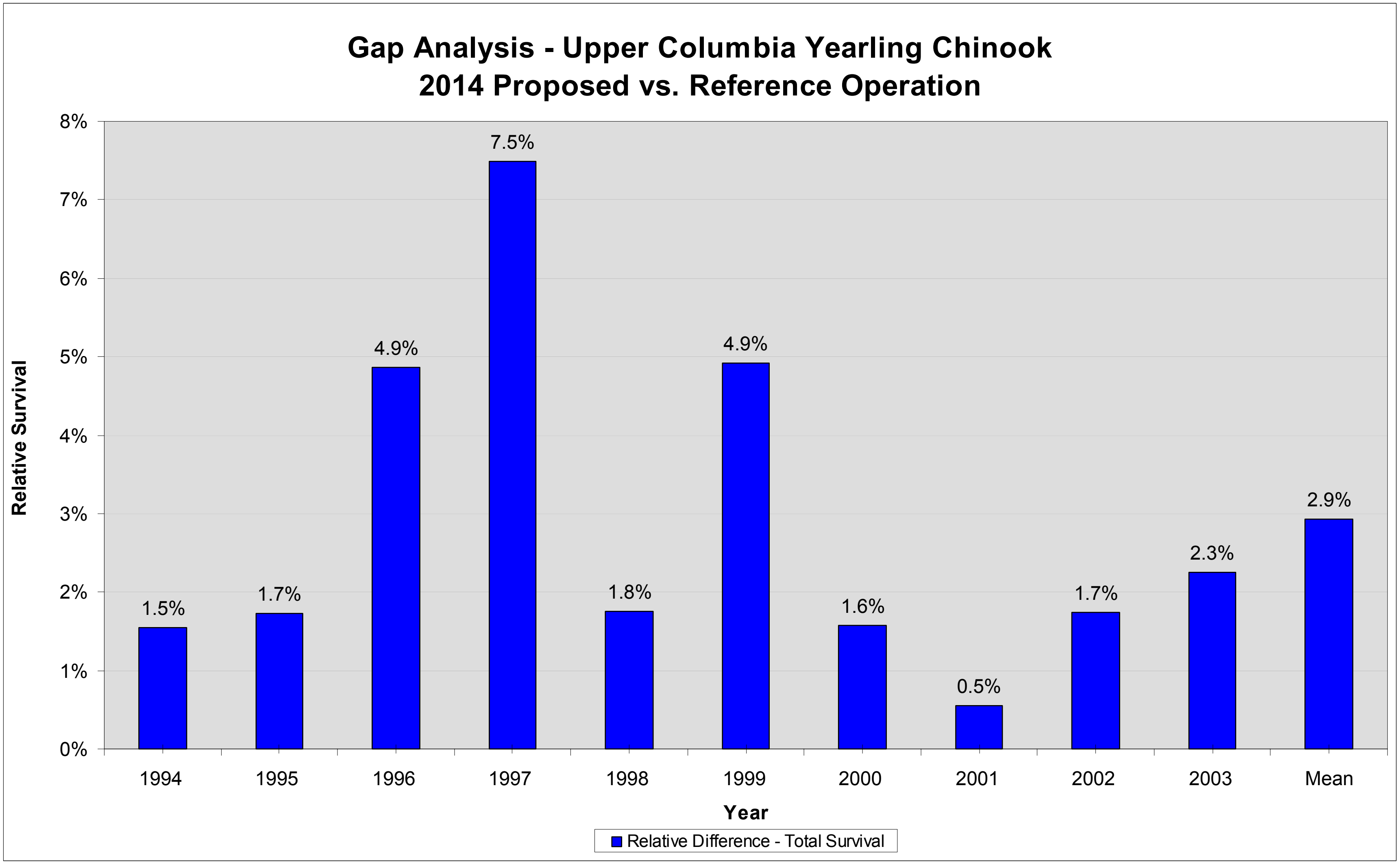

Gap Analysis - Upper Columbia Yearling Chinook
2014 Proposed vs. Reference Operation
Relative Survival
8%
7%
6%
5%
4%
3%
2%
1%
0%
1.5%
1.7%
4.9%
7.5%
1.8%
4.9%
1.6%
0.5%
1.7%
2.3%
2.9%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival

Figure D.13

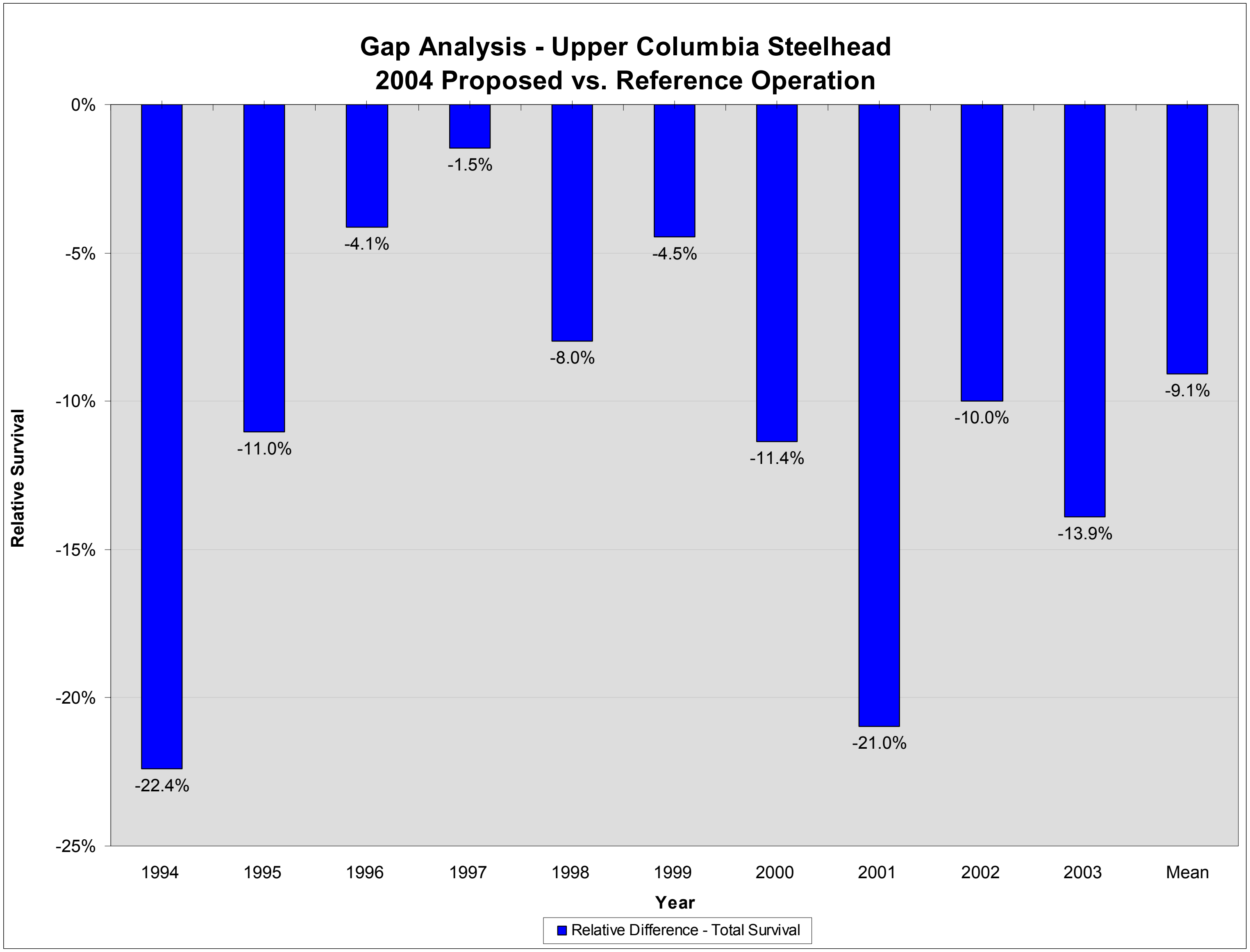

Gap Analysis - Upper Columbia Steelhead
2004 Proposed vs. Reference Operation
0%
-5%
-10%
-15%
-20%
-25%
Relative Survival
-22.4%
-11.0%
-4.1%
-1.5%
-8.0%
-4.5%
-11.4%
-21.0%
-10.0%
-13.9%
-9.1%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival

Figure D.14

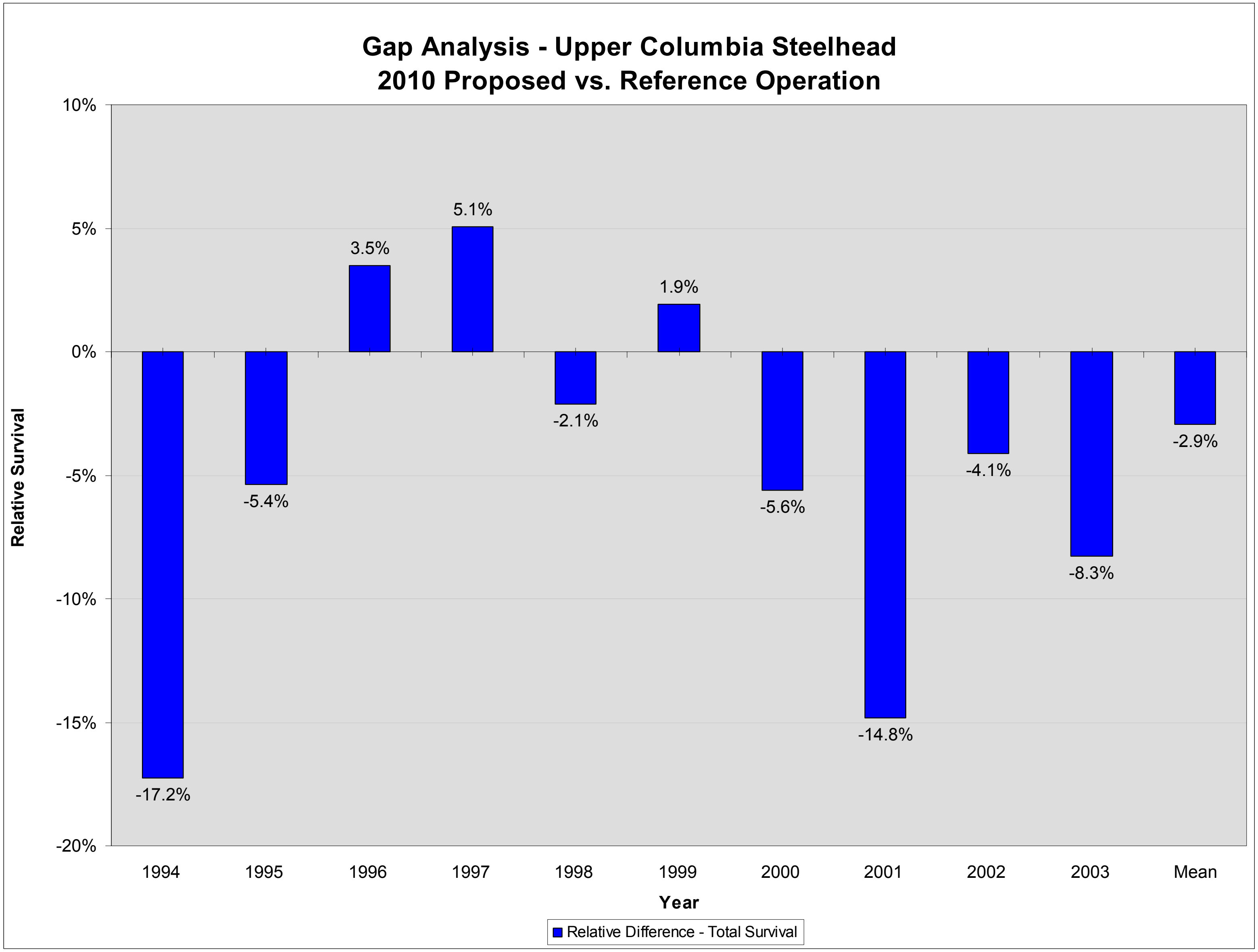
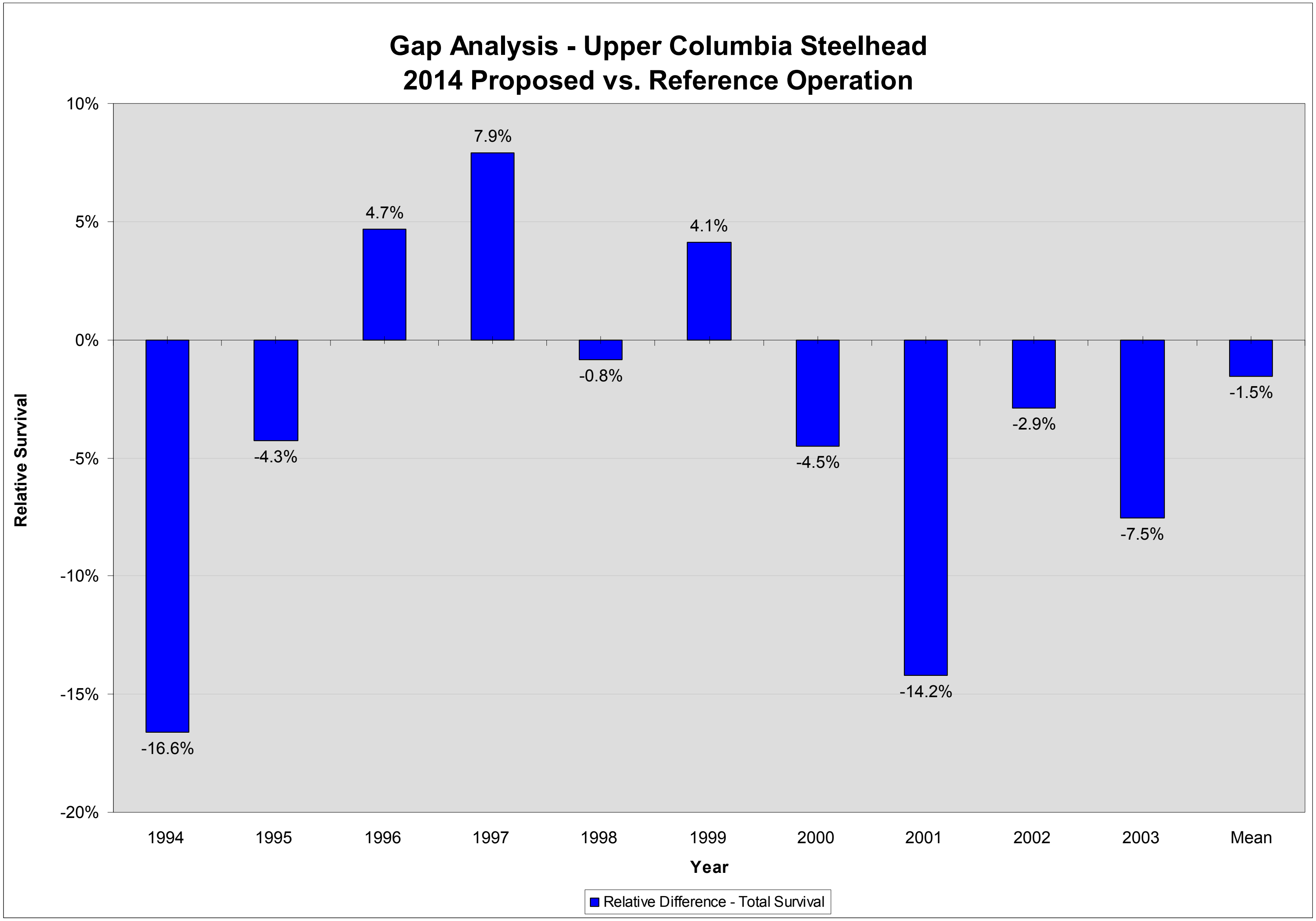

Gap Analysis - Upper Columbia Steelhead
2010 Proposed vs. Reference Operation
10%
5%
0%
-5%
-10%
-15%
-20%
Relative Survival
-17.2%
-5.4%
3.5%
5.1%
-2.1%
1.9%
-5.6%
-14.8%
-4.1%
-8.3%
-2.9%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival

Figure D.15


Gap Analysis - Upper Columbia Steelhead
2014 Proposed vs. Reference Operation
10%
5%
0%
-5%
-10%
-15%
-20%
Relative Survival
7.9%
4.7%
4.1%
-0.8%
-1.5%
-2.9%
-4.3%
-4.5%
-7.5%
-14.2%
-16.6%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival

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